7.6 Temperature is the same.
Temperature α average E_k

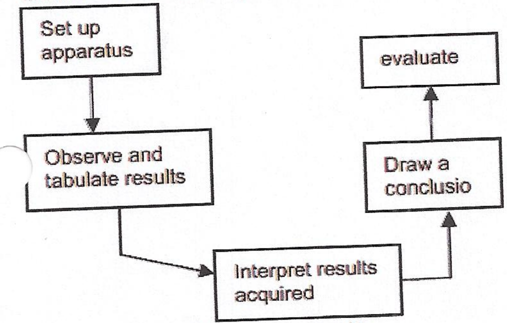
7.7 Same

7.8 Temperature is the same.
Temp directly proportional to Ave KE directly proportional to v^2.

8. Temperature increases proportionally.

Practical activity 1 page 73

Step 1: design a plan
Dependent: Volume
Independent: pressure
Controlled: Temperature

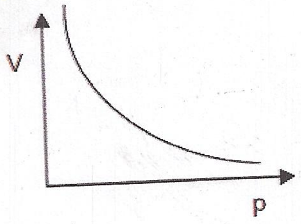


Step 3: Obtain the results

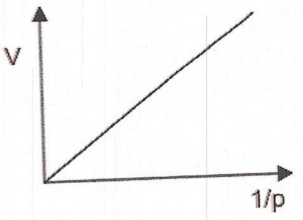
Pressure p (kPa)	Volume V (cm^3)	$\frac{1}{p}$ in kPa^{-1} (x 10^{-3})	pV in J (x10^3)
200	15	5	3
150	20	6,7	3
130	23	7,7	3
100	30	10	3
85,5	35	12	3
71,5	42	14	3
60	50	17	3

Step 4: Obtain the results

1.

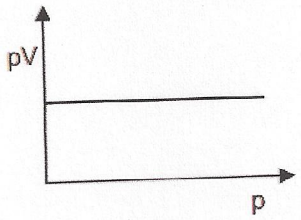


2.



3. $\frac{1}{p} \alpha V$

4.



$$\begin{aligned} pV &= Pa{\cdot}m^3 \\ &= \frac{N}{m^2}{\cdot}m^3 \\ &= kg{\cdot}m^2{\cdot}s^{-2} \\ &= J \end{aligned}$$

5. $p_1V_1 = k$ and $p_2V_2 = k$
So $p_1V_1 = p_2V_2$

Step 5: Conclusion
The results confirm the hypothesis. As the pressure increased the volume decrease proportionally. So that $\frac{1}{V} \alpha\ p$

Application:
They have to swim slowly so as not to get the "benz". Nitrogen gas dissolves in their blood, forming bubbles due to the sudden pressure charges instead of gradual pressure changes. Knowing Boyle's Law would make sense while training to deep sea diving.

Activity 2
Boyle's Law - page 75

1.1 Boyle's Law apparatus

1.2 A – glass tube
B – oil in tube
C – Bourdon pressure gauge
D – Stop cock
E – oil reservoir

1.3 To determine the relationship between volume and pressure of a fixed mass of gas at constant temperature.

1.4.1 Pump air into reservoir, it pushes oil up in glass tube, V decreases, p increases.

1.4.2 Suck air out of reservoir.

1.5.1 Mass of gas

1.5.2 Temperature of gas

1.6 As oil particles slide over each other, it causes friction, friction causes temperature change. Too many variables

1.7.1 Wait a minute or two after changing the pressure before taking the reading.

1.7.2 See that the difference between readings is not too large.

1.8 Water will evaporate and cause a change in the mass of the enclosed gas.

1.9 No, water evaporates easily, which will influence the gas in the tube. It changes the mass of the gas.

1.10 Temperature decreases, particles have less kinetic energy, less volume only after the pressure has been change. Wait 1 minute and the temperature is the same.

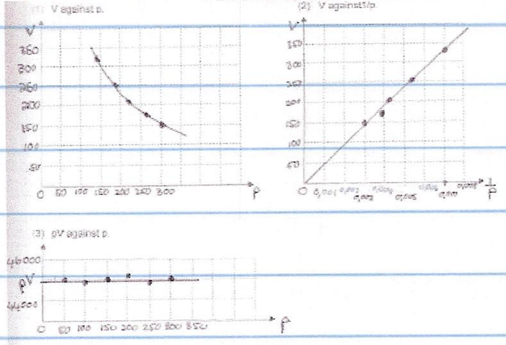
1.11 If the pressure of the gas is increased, I would expect the volume to be affected, if the temperature stays constant.

1.12

$1/p$ (kPa^{-1})	pV
1×10^{-3}	45 000
$7,14 \times 10^{-3}$	44 940
$5,55 \times 10^{-3}$	45 000
$4,54 \times 10^{-3}$	45 100
$3,85 \times 10^{-3}$	44 980
$3,33 \times 10^{-3}$	45 000

1.13 Pressure , x. Volume , y.

1.14



1.15 Graph 1 = hyperbola, Graph 2 = straight line through origin, Graph 3 = straight line parallel to x-axis

1.16 Volume is directly proportional to 1/p OR volume is inversely proportional to pressure..

1.17.1 V directly proportional to 1/p

1.17.2 $pV = k$

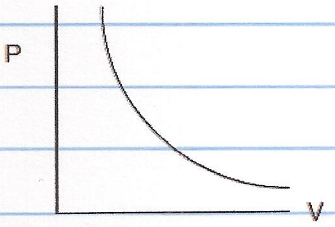
1.17.3 $p_1V_1 = p_2V_2$

1.18 Boyle's Law: The volume of an enclosed mass of gas is inversely proportional to the pressure, provided the temperature remains constant.

1.19 $pV = Pa\ (m^3) = N/m^2\ (m^3)$
$= N.m = J$

2.1 1 – V_1 is twice V_2
2 – same
3 – V_2 twice that of V_1
4 – same – temperature constant
5 – V_2 double that of V_1
6 – V_2 has more than V_1
7 – same

2.2 Boyle's Law
p directly proportional to 1/V



3.1 1 mol gas = $6,02 \times 10^{23}$ particles
thus 0,15 mol = $9,03 \times 10^{22}$ O_2 molecules

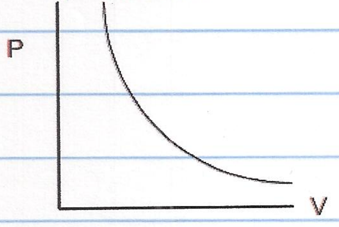
3.2 Boyle's Law

3.3 Inverse proportionality

3.4 $pV = k$ → $180 \times 600 = 108\ 000$ and (end) $270 \times 400 = 108\ 000$.

3.5 $p_1V_1 = p_2V_2$
$432.V_1 = 180 \times 600$
$432V_1 = 108\ 000$
$V_1 = 250\ cm^3$

3.6



4.1 $p_1V_1 = p_2V_2$
$100 \times 20 = 150 \times V_2$
$V_2 = 13,33\ cm^3$

4.2 $p_1V_1 = p_2V_2$
$80 \times 0,5 = p_2 \times 0,08$
$p_2 = 500\ kPa$

5.1 $p_1V_1 = p_2V_2$
$90.V_1 = 200 \times 12$
$V_1 = 26,67\ cm^3$

5.2 $p_1V_1 = p_2V_2$
$120.V_1 = 300 \times 180$
$V_1 = 450\ cm^3$

6.1 $p_1V_1 = p_2V_2$
$100 \times 360 = 120 \times V_2$
$V_2 = 300\ cm^3$

6.2 $p_1V_1 = p_2V_2$
$p_1 \times 4 = 100 \times 6$
$p_1 = 150$ kPa

7.1 100 kPa

7.2 $p_1V_1 = p_2V_2$
$p_1 \times 25 = 100 \times 75$
$p_1 = 300$ kPa
The additional pressure is 200 kPa

8.1 $p_1V_1 = p_2V_2$
$100.V_1 = 0{,}02 \times 2000$
$V_1 = 0{,}4\ m^3$
But each cylinder 0,4 – 0,02
= 0,38 m^3 because
0,02 stay in the cylinder.
Total needed $\frac{20}{0{,}38}$ = 53 cylinders.

8.2 $p_1V_1 = p_2V_2$
$80.V_1 = (2{,}5x10^2) \times 1000$
$V_1 = 3\ 125\ cm^3$
But 1000 cm^3 remains in the
container thus 3 125 – 1000
= 2 125 cm^3 escapes.

9. $p_1V_1 = p_2V_2$
$500.x = 40(x+25)$
$500x = 40x + 1000$
$460x = 1\ 000$
$x = 2{,}17\ cm^3$

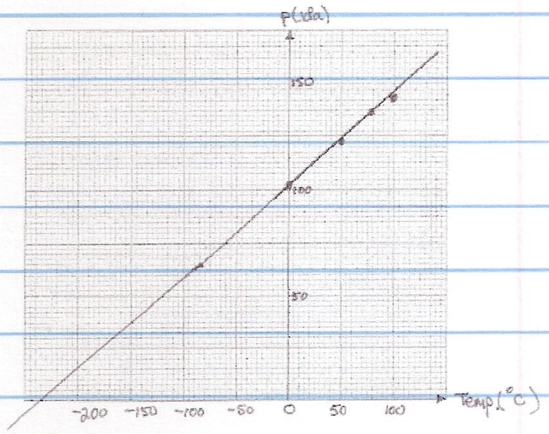
10. As the balloon moves up, the air pressure decreases. Pressure inside the balloon increases, volume of air expands. If the balloon is too full it bursts too soon.

11.1 $p_1V_1 = p_2V_2$
$500 \times 130 = 90 \times V_2$
$V_2 = 722{,}00\ cm^3$
$Y = 722 – 500 = 222{,}22\ cm^3$.

11.2 $p_1V_1 = p_2V_2$
$70 \times 50 = 100 \times V_2$
$V_2 = 35\ cm^3$

Activity 3
Pressure and temperature of a gas. - page 85

1.1 The graph is a straight line not going through the origin



1.2 - 273 ° C

1.3 The pressure of an enclosed mass is directly proportional to the temperature measured in Kelvin if the volume stays constant. T = t + 273,15

1.4 65 kPa

1.5 Increase

2.1 Pressure must be changed by heating the water. The kinetic energy of the particles increases, so collisions increase → pressure increases.

2.2 Volume (flask does not change shape), amount of gas in the flask and the type of gas.

2.3 Temperature in °C and pressure.

2.4 If the pressure of a gas is increased while the volume is kept constant, the temperature will increase.

2.5 Absolute Zero

2.6 0 kPa

2.7 (- 273 °C)

2.8 $\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$\frac{p_1}{273} = \frac{620}{373}$

$p_1 = 453{,}78$ kPa

3.1

°C	K
- 40	**233**
- 23	250
10	**283**
27	300
0	**273**
- 273	0

3.2 Temperature in Kelvin is defined as being directly proportional to the pressure of a given mass of gas at a constant volume.

3.3 1 K = (-272) °C

4.1 $\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$\frac{p_1}{300} = \frac{180}{325}$

$p_1 = 166{,}15 \text{ kPa}$

4.2 $\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$\frac{15}{293} = \frac{30}{T_2}$

$T_2 = 586 \text{ K}$

$t = 313\ ^\circ\text{C}$

5.1 273,15 K or 0°C

5.2 101,3 kPa or 1 atmosphere

6.1 $\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$\frac{70}{300} = \frac{101{,}3}{T_2}$

$T_2 = 434{,}14 \text{ K} = 161^\circ\text{C}$

6.2 $\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$\frac{p_1}{290} = \frac{2p_2}{T_2}$

$T_2 = 580 \text{ K} = 307^\circ\text{C}$

7.1 Initial real pressure
[220 = p_{real} – 101,3 → p_{real} = 321,3 kPa]

$\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$\frac{321{,}3}{298} = \frac{p_2}{343}$

$p_2 = 369{,}8 \text{ kPa}$

The measured pressure
= 369,8 – 101,3 = 268,52 kPa.

7.2 $\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$\frac{100}{373} = \frac{p_2}{393}$

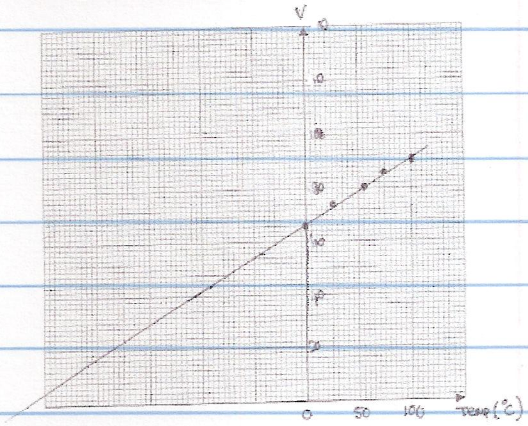
$p_2 = 105{,}36 \text{ kPa}$

8. If the temperature increases, the average kinetic energy will increase. This causes the number of collisions to increase→ pressure will increase resulting in an explosion.

Activity 4

Volume and temperature of a gas – Charles' Law - page 90

1.1 The graph is a straight line not going through the origin



1.2 - 273 °C

1.3 Volume is directly proportional to temperature.

1.4 44 cm^3

1.5 Increase

2.1 Change the temperature by heating the water and read the changes for the volume off the syringe.

2.2 Pressure. By changing the volume the pressure is kept constant.

2.3 Temperature in °C and volume in cm^3

2.4 If the temperature of a fixed mass of gas is changed then the volume changes proportionally – if the pressure is kept constant.

2.5 Absolute Zero

2.6 0 cm^3

2.7 - 273 °C

2.8 $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{9}{373} = \frac{V_2}{273}$

$V_2 = 6{,}59 \text{ cm}^3$

3.1 $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{250}{313} = \frac{V_2}{373}$

$V_2 = 297{,}92 \text{ cm}^3$

3.2 $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{250}{313} = \frac{V_2}{273}$

$V_2 = 218{,}05 \text{ cm}^3$

3.3 $$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

$$\frac{250}{313}=\frac{V_2}{123}$$

$$V_2=98,24\ cm^3$$

3.4 $$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

$$\frac{250}{313}=\frac{V_2}{73}$$

$$V_2=58,31\ cm^3$$

4.1 $$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

$$\frac{32,2}{578}=\frac{28,4}{T_2}$$

$$T_2=509,79K=236,79°C$$

4.2 $$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

$$\frac{60}{300}=\frac{V_2}{350}$$

$$V_2=70\ dm^3$$

4.3 $$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

$$\frac{V}{293}=\frac{2V}{T_2}$$

$$T_2=586K=313°C$$

4.4 $$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

$$\frac{x}{298}=\frac{0,05x}{T_2}$$

$$T_2=14,9\ K$$

14,9K increase =new temp 312,9 K = 39,9 °C

Change in temp = 39,9 – 25 =14,9°C.

Activity 5

The general gas equation –with a constant mass of gas – page 98

1. $$\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$$

2.1 $$\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$$

$$\frac{100(20)}{279}=\frac{105V_2}{303}$$

$$V_2=20,7\ dm^3$$

2.2 $$\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$$

$$\frac{96(236)}{293}=\frac{101,3V_2}{273}$$

$$V_2=208,38\ cm^3$$

3.1 $$\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$$

$$\frac{150(350)}{330}=\frac{p_2 303}{400}$$

$$p_2=180,02\ kPa$$

3.2 $$\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$$

$$\frac{100(600)}{293}=\frac{p_2 10}{153}$$

$$p_2=3133,10\ kPa$$

4.1 $$\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$$

$$\frac{200(30)}{300}=\frac{(250)(32)}{T_2}$$

$$T_2=400\ K=127°\ C$$

4.2 $$\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$$

$$\frac{100(125)}{300}=\frac{p_2 50}{350}$$

$$p_2=291,67\ kPa$$

Change in mass- The general gas equation - page 99

5.1 The general gas equation

5.2 p = pressure in Pa
n = mole in mol
R = universal gas constant in $J.mol^{-1}.K^{-1}$
V = volume in m^3
T = temperature in Kelvin

5.3 $R = \frac{pV}{nT} = \frac{Pa(m^3)}{mol(K)}$

$= \frac{m^3 N \cdot m^{-2}}{mol(K)}$

$= N \cdot m \cdot mol^{-1} \cdot K^{-1}$

$= J \cdot mol^{-1} \cdot K^{-1}$

6.1 The volume of 1 mol of gas at STP

6.2 22,4 dm^3

7.1 $pV = nRT$
$p(20 \times 10^{-3}) = 1,5 \times 8,31 \times 310$
$p = 193,2705$ kPa

7.2 $pV = nRT$
$(249 \times 10^3)(20 \times 10^{-3}) = 2(8,31)T$
$T = 299,62$ K

8. $n = \frac{m}{M} = \frac{8}{32} = 0,25$ mol
$pV = nRT$
$(83 \times 10^3)(4 \times 10^{-3}) = 0,25(8,31)T$
$T = 159,81$ K $= -113,19$ °C

9. $n = \frac{m}{M} = \frac{21}{28} = 0,75$ mol
$pV = nRT$
$(249 \times 10^3)(8 \times 10^{-3}) = 0,75(8,31)T$
$T = 319,61$K $= 46,61$ °C

10.1 $pV = nRT$
$(332 \times 10^3)(12,25 \times 10^{-3}) = n(8,31)305$
$n = 1,60$ mol

10.2 $n = \frac{m}{M}$

$1,6 = \frac{m}{32}$

$m = 51,35$ g

11. $pV = nRT$
$(150 \times 10^3)(0,02) = n(8,31)300$
$n = 1,2$ mol

$n = \frac{m}{M}$

$1,2 = \frac{m}{32}$

$m = 38,51$ g

12.1 $pV = nRT$
$(249 \times 10^3)(20 \times 10^{-3}) = n(8,31)295$
$n = 2,03$ mol

12.2 $n = \frac{m}{M}$

$2,03 = \frac{6}{M}$

$M = 27,56\ g \cdot mol^{-1} = 28\ g \cdot mol^{-1}$
This is N_2

13. $pV = nRT$
$(101,3 \times 10^3)V = 3(8,31)273$
$V = 0,067\ m^3 = 67\ dm^3$

14.1 $pV = nRT$
$(1,4 \times 10^8)(0,8) = n(8,31)298$
$n = 45\ 227,31$ mol

$n = \frac{m}{M}$

$45227,31 = \frac{m}{44}$

$m = 1990001,64$ g $= 1990$ kg

14.2

$pV = nRT$

$p(10 \times 10^{-6}) = 0,5(8,13)350$

$p = \frac{0,5(8,13)350}{10 \times 10^{-6}}$

$= \frac{1422,75}{10 \times 10^{-6}}$

$= 142\ 275\ 000$Pa

$= 142\ 275$ kPa

Activity 6
Ideal gas model – page 104

1.1 It is a gas that obeys the ideal gas law at all pressures and temperatures.

1.2. 1. No attraction or repulsive forces between molecules and walls of container.
2. Elastic
3. Kinetic energy is conserved
4. All particles are identical

2.1 Temperature above 0°C and pressure not too high. Gas molecules move more freely and show behaviour similar to ideal gases.

2.2 He and H_2

3.1 Low temperature and high pressure.

3.2 The forces between particles and the volume of the particles play a strong role in the deviation – as the effect is more visible at low temperature and high pressure.

4.1 $pV = nRT$
$(20 \times 10^3)\ V = 0,5(8,31)293$
$V = 0,0608\ m^3$
$V = 60\ 870,75\ cm^3$

4.2 At very high pressure the forces of repulsion are large and the volume is higher than expected for an ideal gas.

4.3 Smaller. NH_3 has a smaller molar mass so the forces are weaker than O_2.

5.1 $pV = nRT$
$pV = 1 \times 8,31 \times 273$
$= 2268,63\ J = 2,268\ kJ$

5.2 At pressures below 4×10^4 kPa only the attractive forces come into play and the volume will be lower than expected. Particles move closer than predicted.

5.3 Above 4×10^4 kPa the volume of the particles come into play and the volume of the gas is greater than expected forces of repulsion play a larger role.

6.1 Ne and H_2

6.2 At high pressure (not too high) the attractive forces come into play so volume will be smaller than expected.

6.3 At low temperatures, kinetic energy is small; particles move slowly, few collisions occur. Pressure is lower than expected.

Activity 1
Atomic, molecular and formula mass- page 109

1. Carbon was given an atomic mass unit of 12 and all the other elements' masses were then determined in comparison to that of carbon.

2. Relative atomic mass tells us how much more the mass is than Carbon-12 NO UNIT. Atomic mass is this same number but in gram per mol.

3. Because most naturally occurring elements have more than one isotope.

4.1 $M_r(C_2H_6) = 2(12) + 6(1) = 30$
4.2 $M_r(Na_2SO_3) = 2(23) + 32 + 3(16) = 126$
4.3 $M_r(K_2Cr_2O_7) = 2(39)+2(52)+7(16) = 294$
4.4 *There is an error in the book it should be :*
$M_r(Al(OH)_3) = 27 + 3(16+1) = 78$
4.5 $M_r(MgSO_4{\cdot}7H_2O) = 24 + 32 + 4(16) + 7(2+16) = 246$
4.6 $M_r(Cu_3(CO_2)_3(OH)_2$
$= 3(63,5)+3(12+2(16)) + 2(16+1) = 356,5$

5. $M_r(CH_3OH) = 12+4+16 = 32$
$M_r(H_2O) = 16 + 2 = 18$
CH_3OH is 1,78 times heavier than H_2O

Activity 2
The mole: measure of amount of substance - page 114

1. A mole is the amount of substance that contains the same number of particles as there are present in C_{12}.

2.1 $M(Mg) = 24\ g{\cdot}mol^{-1}$
$n = \frac{m}{M} = \frac{12}{24} = 0,5\ mol$

2.2 $M(NH_3) = 17\ g{\cdot}mol^{-1}$
$n = \frac{m}{M} = \frac{24}{17} = 1,41\ mol$

2.3 $M(SO_2) = 64\ g{\cdot}mol^{-1}$
$n = \frac{m}{M} = \frac{6,4}{64} = 0,1\ mol$

2.4 $M(H_2O) = 18\ g{\cdot}mol^{-1}$
$n = \frac{m}{M} = \frac{1,4}{18} = 0,083\ mol$

3.1 $M(CO_2) = 44\ g{\cdot}mol^{-1}$
$n = \frac{m}{M}$
$0,6 = \frac{m}{44}$
$m = 26,4\ g$

3.2 $M(HC\ell) = 36,5\ g{\cdot}mol^{-1}$
$n = \frac{m}{M}$
$10 = \frac{m}{36,5}$
$m = 365\ g$

3.3 $M(CaCO_3) = 100\ g{\cdot}mol^{-1}$
$n = \frac{m}{M}$
$0,25 = \frac{m}{100}$
$m = 25\ g$

3.4 $M_{(NaOH)} = 40\ g{\cdot}mol^{-1}$
$n = \frac{m}{M}$
$1 = \frac{m}{40}$
$m = 40\ g$

4. 1 mol of any substance contains $6,02 \times 10^{23}$ particles.

5.1 $6,02 \times 10^{23}$ C_2F_{10} molecules
5.2 $1,204 \times 10^{24}$ C atoms
5.3 $6,02 \times 10^{24}$ F atoms
5.4 $7,224 \times 10^{24}$ atoms

6.1 $M_{(Na)}= 23\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{0,23}{23}=0,01\text{ mol}$$

6.2 1 mol Na = $6,02 \times 10^{23}$ Na atoms
0,01 mol Na = $6,02 \times 10^{21}$ Na atoms.

7.1 $M_{(H2)}= 2\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{4}{2}=2\text{ mol}$$

7.2 1 mol H_2 = $6,02 \times 10^{23}$ H_2 molecules
2 mol H_2 = $1,204 \times 10^{24}$ H_2 molecules
But 1 molecule H_2 = 2 H atoms
Thus .
2 mol H_2 molecules = $2,408 \times 10^{24}$ H atoms

8.1 1 $M(NH_3)= 17\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{42,5}{17}=2,5\text{ mol}$$

1 mol NH_3 = $6,02 \times 10^{23}$ NH_3 molecules
2,5 mol NH_3 = $1,505 \times 10^{24}$ NH_3 molecules

8.2 $M(Na\ell)_{)}= 27\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{0,9}{27}=0,033\text{ mol}$$

1 mol Aℓ = $6,02 \times 10^{23}$ Al atoms
0,033 mol Aℓ = $2,0667 \times 10^{22}$ Aℓ atoms

8.3 $M(H_2O)= 18\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{27}{18}=1,5\text{ mol}$$

1 mol H_2O = $6,02 \times 10^{23}$ H_2O molecules
1,5 mol H_2O = $9,03 \times 10^{23}$ H_2O molecules

8.4 $M(HNO_3)= 63\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{2,1}{63}=0,033\text{ mol}$$

1 mol = $6,02 \times 10^{23}$ HNO_3 molecules
0,033mol = $2,006 \times 10^{22}$ HNO_3 molecules

9.1 $M(KMnO_4)= 158\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{43}{158}=0,27\text{ mol}$$

1 mol = $6,02 \times 10^{23}$ $KMnO_4$ molecules
0,27 mol K = $1,6 \times 10^{23}$ $KMnO_4$ molecules

1 molecule $KMnO_4$ = 1 K^+ ions
Thus
1 mol K^+ in $KMnO_4$= $6,02 \times 10^{23} K^+$ions
Therefore 0,27 mol K^+ ions in $KMnO_4$
= $1,6 \times 10^{23}$ K^+ ions.

9.2 $M(K_2SO_4)= 174\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{2}{174}=0,011\text{ mol}$$

(1)
1 mol = $6,02 \times 10^{23}$ K_2SO_4 molecules
0,011 mol K = $6,919 \times 10^{21}$ K_2SO_4 molecules

But 1 molecule K_2SO_4 = 2 K^+ ions
Thus
0,011 mol K_2SO_4 molecules
= $1,38 \times 10^{22}$ K^+ ions.

(2)
But 1 molecule K_2SO_4 = 1 SO_4^{2-} ion
Thus
0,011 mol K_2SO_4 molecules
= $6,919 \times 10^{21}$ SO_4^{2-} ions

9.3 $M(C_3O_2H_6)= 74\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{74}{74}=1\text{ mol}$$

1 mol = $6,02 \times 10^{23}$ $C_3O_2H_6$ molecules

(1)
But 1 molecule $C_3O_2H_6$= 3 C atoms
Thus .
1 mol $C_3O_2H_6$ molecules
= $1,806 \times 10^{24}$ C atoms.

(2)
But 1 molecule $C_3O_2H_6$= 6 H atoms
Thus .
1 mol $C_3O_2H_6$ molecules
= $3,612 \times 10^{24}$ H atoms

9.4 $M(Na_2SO_4)= 142\ g\cdot mol^{-1}$

$$n=\frac{m}{M}=\frac{106,5}{142}=0,75\text{ mol}$$

(1)
1 mol = $6,02 \times 10^{23}$ Na_2SO_4 molecules

mol N: $n = \frac{m}{M} = \frac{28{,}8}{14} = 2{,}057$ mol

mol O: $n = \frac{m}{M} = \frac{16{,}6}{16} = 1{,}037$ mol

x : y : z : p
4,125 : 5,2 : 2,057 : 1,037
3,977 : 5 : 1,98 : 1
4 : 5 : 2 :1

$C_4H_5N_2O$

7. N_x:O_y

N: $n = \frac{m}{M} = \frac{39{,}8}{14} = 2{,}63$ mol

O: $n = \frac{m}{M} = \frac{63{,}2}{16} = 3{,}95$ mol

x : y
2,63 : 3,95
1 : 1,5
2 : 3

N_2O_3

8.1 $C_xH_yO_z$

C: $n = \frac{m}{M} = \frac{39{,}9}{12} = 3{,}325$ mol

H: $n = \frac{m}{M} = \frac{6{,}7}{1} = 6{,}7$ mol

O: $n = \frac{m}{M} = \frac{53{,}4}{16} = 3{,}337$ mol

X : y : z
3,3325 : 6,7: 3,337
1 : 2 : 1

CH_2O

8.2 $M(CH_2O) = 12+ 12 + 16 = 30\ g{\cdot}mol^{-1}$

$\frac{\text{molecular mass}}{\text{emperical mass}} = \frac{60}{30} = 2$

molecular formula $C_2H_4O_2$

9.1 $C_xH_yN_z$

C: $\frac{m}{M} = \frac{74}{12} = 6{,}166$ mol

H: $\frac{m}{M} = \frac{8{,}65}{1} = 8{,}65$ mol

N: $\frac{m}{M} = \frac{17{,}35}{14} = 1{,}239$ mol

x : y : z
6,166 : 8,65 : 1,239
5 : 7 : 1

C_5H_7N

9.2 $M(C_5H_7N) = 5(12)+ (1)+14 = 81\ g{\cdot}mol^{-1}$

$\frac{\text{molecular mass}}{\text{emperical mass}} = \frac{162}{81} = 2$

Molecular formula $C_{10}H_{14}N_2$

10. $C_xH_yO_z$

The percentage of oxygen was left out in book. Should be 34,408%

C: $\frac{m}{M} = \frac{58{,}065}{12} = 4{,}839$ mol

H: $\frac{m}{M} = \frac{7{,}527}{1} = 7{,}527$ mol

O: $\frac{34{,}408}{16} = 2{,}151$ mol

x : y : z
4,839 : 7,527 : 2,151
2,25 : 3,5 : 1
9:14:4

$C_9H_{14}O_4$

$M(C_9H_{14}O_4) = 9(12)+14(1)+4(16) = 186\ g{\cdot}mol^{-1}$

$\frac{\text{molecular mass}}{\text{emperical mass}} = \frac{186}{186} = 1$

Molecular formula $C_9H_{14}O_4$

11. $C_xH_y + O_2 \rightarrow CO_2 + H_2O$
15 g 51,45g 47,1g 19,35g

O_2 : $n = \frac{m}{M} = \frac{51{,}45}{32} = 1{,}607$ mol

CO_2: $n = \frac{m}{M} = \frac{47{,}1}{12+2(16)} = 1{,}07$ mol

H_2O: $n = \frac{m}{M} = \frac{19{,}35}{18} = 1{,}075$ mol

O_2 : CO_2 : H_2O
1,607 : 1,07 : 1,075
1,5 : 1 : 1
3 : 2 : 2

$C_xH_y + 3O_2 \rightarrow 2CO_2 + 2H_2O$

So $C_xH_y = C_2H_4$

12. $C_xH_y + O_2 \rightarrow CO_2 + H_2O$
20 g 61,54g 67,69g 13,85 g

O_2 : $n = \frac{m}{M} = \frac{61{,}54}{32} = 1{,}923$ mol

CO_2: $n = \frac{m}{M} = \frac{67{,}69}{12+2(16)} = 1{,}54$ mol

H_2O: $n = \frac{m}{M} = \frac{13{,}85}{18} = 0{,}77$ mol

O_2 : CO_2 : H_2O
1,923 : 1,54 :0,77
2,5 : 2 : 1
5 : 4 : 2

$C_xH_y + 5O_2 \rightarrow 4CO_2 + 2H_2O$

So $C_xH_y = C_4H_4$

13. $C_xH_yO + O_2 \rightarrow CO_2 + H_2O$

14,3 mg 43,2 mg 44 mg 13,5 mg

$O_2 : n = \frac{m}{M} = \frac{0,0432}{32} = 0,00135$ mol

$CO_2 : n = \frac{m}{M} = \frac{0,044}{12+2(16)} = 0,001$ mol

$H_2O : n = \frac{m}{M} = \frac{0,0135}{18} = 0,00075$ mol

$O_2 : CO_2 : H_2O$

0,00135 : 0,001 : 0,00075

1,35 : 1 : 0,75

135 : 100 : 75

27 : 20 : 15

$C_xH_yO + 27O_2 \rightarrow 20CO_2 + 15H_2O$

So $C_xH_y = C_{20}H_{30}O$

14. $C_xH_yO + O_2 \rightarrow CO_2 + H_2O$

1,86 g 2,4 g 2,64g 1,62g

$O_2 : n = \frac{m}{M} = \frac{2,4}{32} = 0,075$ mol

$CO_2 : n = \frac{m}{M} = \frac{2,64}{12+2(16)} = 0,06$ mol

$H_2O : n = \frac{m}{M} = \frac{1,62}{18} = 0,09$ mol

$O_2 : CO_2 : H_2O$

0,075 : 0,06 : 0,09

1,25 : 1 : 1,5

5 : 4 : 6

$C_xH_yO + 5O_2 \rightarrow 4CO_2 + 6H_2O$

So $C_xH_y = C_4H_{12}O_4$

Activity 4
Practical quantitative methods to determine chemical composition – page 128

1.1 Magnesium reacts to completion with oxygen to form magnesium oxide

1.2 Mass magnesium oxide and mass oxygen

1.3

Mass of magnesium used	0,24 g
Mass of magnesium oxide formed	0,40 g
Mass of oxygen used	0,16 g

1.4 $n = \frac{m}{M} = \frac{0,24}{24} = 0,01$ mol magnesium

$n = \frac{m}{M} = \frac{0,16}{16} = 0,01$ mol oxygen

1.5 Ratio is 1:1

so empirical formula is MgO

2.1 Let the H_2 gas first flow through the tube for a while before you ignite it.

The tube must be cool down when the H_2 is passed through it.

Wear goggles and lab coat

2.2 Copper oxide reacts with hydrogen to form water and copper.

2.3 mass copper formed

2.4 Amount of water vapour

2.5 Determine the mass of the test tube before the experiment.

Determine the mass of the test tube with the CuO in it before heating.

Determine the mass of the test tube with the product in it after heating.

2.6

Mass of copper(IV)oxide used	1,6 g
Mass copper formed	1,28 g
Mass of oxygen in copper(IV)oxide	0,32 g

2.7 $n = \frac{m}{M} = \frac{1,28}{63,5} = 0,02$ mol copper

$n = \frac{m}{M} = \frac{0,32}{16} = 0,02$ mol oxygen

2.8 Ratio 1:1 so CuO

3.1 $n = \frac{m}{M} = \frac{3,93}{159,5} = 0,0246$ mol $CuSO_4$

Exp 1: m = 4,836 g

Exp 2: m = 3,48 g

Exp 3: m = 3,48 g

Average = 3,93 g

$n = \frac{m}{M} = \frac{1,511}{18} = 0,083$ mol H_2O

Exp 1: m = 0,607 g

Exp 2: m = 1,963 g

Exp 3: m = 1,963 g

Averagge = 1,511 g

3.2 0,0218 : 0,109

1 : 5

$CuSO_4{\cdot}5H_2SO_4$

3.3 Repeat experiment

3.4 white power was not dry enough

Activity 5
Stoichiometric calculations – page 143

1.1 $4NH_3 + 5O_2 \rightarrow 4NO + 6\,H_2O$

1.2 $NH_3 : O_2$

4 : 5

1 : 1,25

so 1,25 mol O_2 needed

1.3 $n = \frac{m}{M}$

$1,25 = \frac{m}{32}$

m = 40 g

2.1 $N_2 : H_2 : NH_3$

1 : 3 : 2

so 2 mol NH_3 forms

2.2 1 mol H_2 has 6,02 x 10^{23} molecules H_2

x mol H_2 has1,806 x 10^{24} molecules H_2

so x = 3 mol

$H_2 : NH_3$

3 : 2

so 2 mol NH_3 forms

2.3 $N_2 : H_2 : NH_3$

1 : 3 : 2

0,2: 0,6 :0,4

so 0,4 mol NH_3 forms

3.1 $2SO_2 + O_2 \rightarrow 2SO_3$

3.2 $SO_2 : O_2 : SO_3$

2 : 1 :2

3 : 1,5: 3

so 3 mol SO_3 forms

3.3 $SO_2 : O_2 : SO_3$

2 : 1 :2

4 : 2 : 4

Only 2 mol O_2 is used so 4 mol SO_2 needed.

3.4 4 mol O_2

3.5 SO_2: $n = \frac{m}{M} = \frac{160}{64} = 2,5$ mol

$SO_2 : SO_3$

2,5 : 2,5

SO_3: $n = \frac{m}{M} = \frac{m}{80} = 2,5$

m = 200 g SO_3 formed

3.6 1 mol SO_2 are 6,02 x 10^{23} molecules SO_3

2,5 mol SO_2 are 1,51 x 10^{24} molecules SO_3

3.7 O_2: $n = \frac{m}{M} = \frac{8}{32} = 0,25$ mol

$O_2 : SO_3$

1 : 2

So SO_3: $n = \frac{m}{M}$

$0,5 = \frac{m}{80}$

m = 40 g

8 g of O_2 will produce only 40 g SO_3 not 80 g.

4.1 $N_2 : O_2 : NO_2$

1 : 2 : 2

0,5: 1 : 1

so 1 mol O_2 combines with 0,5 mol N_2

4.2 $N_2 : O_2 : NO_2$

1 : 2 : 2

5 : 10 : 10

10 mol NO_2 forms

4.3 N_2: $n = \frac{m}{M} = \frac{21}{28} = 0,75$ mol

$N_2 : NO_2$

1 : 2

0,75: 1,5

NO_2: $n = \frac{m}{M}$

$1,5 = \frac{m}{46}$

m = 69 g NO_2 forms

5. $PC\ell_3$: $n = \frac{m}{M} = \frac{20}{137,5} = 0,1445$ mol

$PC\ell_3 : HC\ell$

1 : 3

0,1445:0,436

$HC\ell$: $n = \frac{m}{M}$

$0,436 = \frac{m}{36,5}$

m = 15,93 g $HC\ell$

6. $HC\ell$: $n = \frac{m}{M} = \frac{2}{36,5} = 0,0547$ mol

$HC\ell : NaHCO_3$

1 : 1

0,0547 : 0,0547

$NaHCO_3$: $n = \frac{m}{M}$

$0,436 = \frac{m}{84}$

m = 4,6 g

7.1 $2\,KC\ell O_3 \rightarrow 2\,KC\ell + 3O_2$

O_2: $n = \frac{m}{M} = \frac{19,2}{32} = 0,6$ mol

$KC\ell O_3 : O_2$

2 : 3

0,4 : 0,6

$KC\ell O_3 : : n = \frac{m}{M}$

$0,4 = \frac{m}{122,5}$

$m = 49\ g\ KC\ell O_3$

7.2 $O_2: n = \frac{m}{M} = \frac{19,2}{32} = 0,6\ mol$

$1\ mol\ O_2 = 6,02 \times 10^{23}$ molecules

So

$0,6\ mol\ O_2 = 3,612 \times 10^{23}$ molecules

8. $S: n = \frac{m}{M} = \frac{3000}{32} = 93,75\ mol$

$S : SO_2$
1 : 1
93,75: 93,75

$SO_2: n = \frac{m}{M}$

$93,75 = \frac{m}{64}$

$m = 6000\ g = 6\ kg\ SO_2$ formed

9. no number 9 in book

10.1 $A\ell : C\ell_2$
2 : 3
1,5 : 2,25
If 1,5 mol $A\ell$ is used only 2,25 mol of $C\ell_2$ would be used
$A\ell$ is the limiting reactant

10.2 $A\ell : C\ell_2 : A\ell C\ell_3$
2 : 3 : 2
1,5 : 2,25 : 1,5
so 1,5 mol $A\ell C\ell_3$ can be produced

10.3 We had 3 mol but only 2,25 mol of $C\ell_2$ was used, so 3 – 2,25 = 0,75 mol $C\ell_2$ was in excess

11.1 $NaOH : CO_2 : Na_2CO_3 : H_2O$
2 : 1 : 1 : 1
1,85 :0,925: 0,925 : 0,925
NaOH is the limiting reactant

11.2 $NaOH : Na_2CO_3$
2 : 1
1,85 : 0,925
0,925 mol Na_2CO_3 forms

11.3 We had 1 mol CO_2 and used 0,952 mol so 1 – 0,952 = 0,075 mol CO_2 left

12.1 $NH_4NO_3 : n = \frac{m}{M} = \frac{30}{80} = 0,375\ mol$

$Na_3PO_4: n = \frac{m}{M} = \frac{50}{164} = 0,305\ mol$

$NH_4NO_3 : Na_3PO_4$
3 : 1
0,375 : 0,125
so NH_4NO_3 is limiting

12.2 $NH_4NO_3 : (NH_4)_3PO_4 : NaNO_3$
3 : 1 : 3
0,375 : 18,625 : 31,875

12.3 (0,305 mol Na_3PO_4 given) – (0,125 mol Na_3PO_4 used) = 0,18 mol Na_3PO_4 left over

13.1 $CaCO_3: n = \frac{m}{M} = \frac{100}{100} = 1\ mol$

$FePO_4: n = \frac{m}{M} = \frac{45}{151} = 0,298\ mol$

$CaCO_3 : FePO_4$
3 : 2
1 : 0,666
If all $CaCO_3$ is used, there is not enough $FePO_4$ are present. Therefore the limiting reactant is $FePO_4$

13.2 $FePO_4 : Ca_3(PO_4)_2 : Fe_2(CO_3)_3$
2 : 1 : 1
0,298 : 0,149 : 0,149
so 0,149 mol $Ca_3(PO_4)_2$ = 46,19 g is produced
so 0,149 mol $Fe_2(CO_3)_3$ = 43,51 g is produced

13.3 $CaCO_3 : FePO_4$
3 : 2
0,447 : 0,298
(1 mol $CaCO_3$ given) – (0,44 mol $CaCO_3$ was used) = 0,553 mol $CaCO_3$ left

14.1 $O_3: n = \frac{m}{M} = \frac{0,74}{16(3)} = 0,015\ mol$

$NO: n = \frac{m}{M} = \frac{0,67}{14+16} = 0,022\ mol$

14.2 $O_3 : NO$
1 : 1
0,015: 0,015
If 0,015 mol O_3 were used then only 0,015 mol of the NO will be used and 0,007 mol NO left. So O_3 is the limiting reactant.

14.3 $O_3 : NO_2$
1 : 1
0,015 : 0,015

$NO_2: n = \frac{m}{M}$

$0,015 = \frac{m}{14 + 2(16)}$

$m = 0,69\ g$

15. $\% \text{ yield} = \frac{26,6}{36,44} \times 100 = 73\%$

16. $\% \text{ yield} = \frac{7,5}{15,94} \times 100 = 47,1\%$

17.1 CH_3OH: $n = \frac{m}{M} = \frac{125}{32} = 3,91 \text{ mol}$

$CH_3OH : H_2$

1 : 2

3,91 : 7,82

$H_2 : n = \frac{m}{M}$

$7,82 = \frac{m}{2}$

$m = 15,63 \text{ g } H_2$

17.2 $\% \text{ yield} = \frac{13,6}{15,63} \times 100 = 87\%$

18.1 $CaCO_3$: $n = \frac{m}{M} = \frac{50}{100} = 0,5 \text{ mol}$

$CaCO_3 : CO_2$

1 : 1

0,5 : 0,5

CO_2: $n = \frac{m}{M}$

$0,5 = \frac{m}{44}$

m = 22 g

22 g CO_2 captured

18.2 CO_2: $n = \frac{m}{M} = \frac{18,2}{44} = 0,414 \text{ mol}$

$CO_2 : CaCO_3$

1 : 1

0,414: 0,414

$CaCO_3 : n = \frac{m}{M}$

$0,414 = \frac{m}{100}$

m = 41,4 g

$\% \text{ purity} = \frac{41,41}{50} \times 100 = 82,8\%$

18.3 $\% \text{ purity} = 70\ \% = \frac{m}{50} \times 100$

so m = 35 g $CaCO_3$

$CaCO_3$: $n = \frac{m}{M} = \frac{35}{100} = 0,35 \text{ mol}$

$CaCO_3 : CO_2$

1 : 1

0,35 : 0,35

CO_2: $n = \frac{m}{M}$

$0,35 = \frac{m}{44}$

$m = 15,4 \text{ g } CO_2$

Activity 6

Calculations involving gasses – page 154

1.1 $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$

$\frac{800(105)}{320} = \frac{V_2(10^6)}{300}$

$V_2 = 75 \text{ cm}^3$

1.2 $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$

$\frac{800(10^5)}{320} = \frac{V_2(250 \times 10^3)}{250}$

$V_2 = 250 \text{ cm}^3$

1.3 $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$

$\frac{800(10^5)}{320} = \frac{V_2(101,3 \times 10^3)}{273}$

$V_2 = 673,74 \text{ cm}^3$

2. $pV = nRT$

$(101,3 \times 10^3)V = 1(8,31)(273)$

$V = 0,0224 \text{ m}^3 = 22,4 \text{ dm}^3$

called the molar volume

3. $n = \frac{m}{M} = \frac{24}{32} = 0,75 \text{ mol}$

$pV = nRT$

$(249 \times 10^3)(4 \times 10^{-3}) = (0,75)(8,31)T$

T = 159,8 K

4. $pV = nRT$

$(101,3 \times 10^3)(0,0041) = n(8,31)(310)$

n = 0,161 mol

5.1 $pV = nRT$

$(99,3 \times 10^3)(65 \times 10^{-3}) = n(8,31)(298)$

n = 2,6 mol

$n = \frac{m}{M}$

$2,6 = \frac{m}{28}$

m = 72,97 g

5.2 As the temperature increases (from 25°C to 35°C) the number of collisions increase because temperature is the measure of the average E_k of the gas. Therefore the pressure increases.

6.1 $pV = nRT$

$(101{,}3 \times 10^3)V = 0{,}46(8{,}31)(298)$

$V = 0{,}01125\ m^3$

6.2 Zn: $n = \frac{m}{M} = \frac{30}{65} = 0{,}46$ mol

Zn : H_2

1 : 1

0,46 : 0,46

H_2 : $n = \frac{m}{M}$

$0{,}46 = \frac{m}{2}$

$m = 0{,}92$ g

7. $2NaN_3\ (s) \rightarrow 2\ Na\ (s) + 3\ N_2(g)$

NaN_3: $n = \frac{m}{M} = \frac{150}{65} = 2{,}3$ mol

NaN_3 : N_2

2 : 3

2,3: 3,45

$pV = nRT$

$(101{,}3 \times 10^3)V = 3{,}45(8{,}31)(303)$

$V = 0{,}086\ m^3$

8.1 $C_{23}H_{48} + 35O_2 \rightarrow 23CO_2 + 24H_2O$

8.2 $C_{23}H_{48}$: $n = \frac{m}{M} = \frac{25}{324} = 0{,}077$ mol

$C_{23}H_{48}$: O_2

1 : 35

0,077 : 2,701

$pV = nRT$

$(101{,}3 \times 10^3)V = 2{,}701(8{,}31)(273)$

$V = 0{,}06\ m^3$

8.3 $C_{23}H_{48}$: CO_2

1 : 23

0,077 : 1,771

CO_2: $n = \frac{m}{M}$

$1{,}771 = \frac{m}{44}$

$m = 77{,}92$ g

Activity 7

Concentration of the solution – page 160

1. The amount of substance dissolved per volume of solution.

2.1 $c = \frac{n}{V}$

$0{,}5 = \frac{n}{3}$

n=1,5 mol

2.2 $c = \frac{n}{V}$

$0{,}5 = \frac{n}{0{,}02}$

n=0,01 mol

3.1 $n = \frac{m}{M} = \frac{3{,}65}{36{,}5} = 0{,}1$ mol

$c = \frac{n}{V}$

$= \frac{0{,}1}{1}$

$= 0{,}1\ mol \cdot dm^{-3}$

3.2 $n = \frac{m}{M} = \frac{1{,}09}{119} = 0{,}00915$ mol

$c = \frac{n}{V}$

$= \frac{0{,}00915}{0{,}1}$

$= 0{,}091\ mol \cdot dm^{-3}$

3.3 $n = \frac{m}{M} = \frac{1{,}58}{158} = 0{,}01$ mol

$c = \frac{n}{V}$

$= \frac{0{,}01}{0{,}5}$

$= 0{,}02\ mol \cdot dm^{-3}$

3.4 $n = \frac{m}{M} = \frac{9{,}8}{98} = 0{,}1$ mol

$c = \frac{n}{V}$

$= \frac{0{,}01}{0{,}25}$

$= 0{,}4\ mol \cdot dm^{-3}$

4.1 $c = \frac{n}{V}$

$0{,}1 = \frac{n}{0{,}2}$

n=0,02 mol

$n = \frac{m}{M}$

$0,02 = \frac{m}{58,5}$

$m = 1,17$ g

4.2 $c = \frac{n}{V}$

$0,5 = \frac{n}{0,1}$

$n = 0,05$ mol

$n = \frac{m}{M}$

$0,05 = \frac{m}{56}$

$m = 2,8$ g

4.3 $c = \frac{n}{V}$

$0,01 = \frac{n}{1}$

$n = 0,01$ mol

$n = \frac{m}{M}$

$0,01 = \frac{m}{126}$

$m = 1,26$ g

4.4 $c = \frac{n}{V}$

$0,2 = \frac{n}{0,05}$

$n = 0,01$ mol

$n = \frac{m}{M}$

$0,01 = \frac{m}{246}$

$m = 2,46$ g

5.1 $n = \frac{m}{M}$

$= \frac{6,7}{106}$

$n = 0,063$ mol

$c = \frac{n}{V}$

$= \frac{0,063}{0,25}$

$= 0,253 \text{ mol}\cdot\text{dm}^{-3}$

5.2 $Na_2CO_3 : Na^+ : CO_3^{2-}$

$1 : 2 : 1$

$0,063 : 0,126 : 0,063$

Na^+:

$c = \frac{n}{V}$

$= \frac{0,126}{0,25}$

$= 0,504 \text{ mol}\cdot\text{dm}^{-3}$

CO_3^{2-}:

$c = \frac{n}{V}$

$= \frac{0,063}{0,25}$

$= 0,252 \text{ mol}\cdot\text{dm}^{-3}$

6. A solution of which the concentration is known.

7. $c = \frac{n}{V}$

$0,01 = \frac{n}{0,5}$

$n = 0,05$ mol

$n = \frac{m}{M}$

$0,05 = \frac{m}{40}$

$m = 2$ g

I will, in a watch glass, measure the 2 g of NaOH on a balance and then add 500 cm^3 distilled water to NaOH.

Practical Activity – page 164

Enter your readings:

Volume NaOH transfered	20 cm^3
Concentration NaOH	0,1 $mol\cdot dm^{-3}$
Volume of Acid at A	50 cm^3
Volume of Acid at B	24 cm^3
Volume of Acid at C	26 cm^3

Calculate the concentration of the acid:

1. $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

2. $\frac{n_a}{n_b} = \frac{c_a V_a}{c_b V_b}$

$\frac{1}{2} = \frac{c_a(26 \times 10^{-3})}{0,1(20 \times 10^{-3})}$

$c_a = 0,038 \text{ mol}\cdot\text{dm}^{-3}$

Hypothesis and variables

1. The concentration of an acid can be determined by doing a titration with a base of known titration.
2. Dependent variable: Volume titrated
   Independent variable: [NaOH]

Application in technology, community and environment

Whenever neutralisation of a substance has to occur. E.g. heartburn, acid spills

Activity 8
Titrations – page 165

1.1 $HC\ell + NaOH \rightarrow NaC\ell + H_2O$

1.2 $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

1.3 $2HC\ell + CaCO_3 \rightarrow CaC\ell_2 + H_2O + CO_2$

1.4 $H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2$

2.1 A: conical flask or Erlenmeyer beaker
B: burette
C: pipette

2.2 C - Pipette

2.3 A - conical flask or Erlenmeyer flask

2.4 bromothymol blue in conical flask

2.5 $HC\ell + NaOH \rightarrow NaC\ell + H_2O$

2.6 $66 - 35 = 31\ cm^3$

2.7 Base: $n = CV = 0{,}25(0{,}05)$
$= 0{,}0125$ mol

$HC\ell : NaOH$
1 : 1
0,0125 : 0,0125

acid: $C = \frac{n}{V} = \frac{0{,}0125}{0{,}031}$
$= 0{,}403\ mol{\cdot}dm^{-3}$

3. acid: $C = \frac{n}{V}$

$0{,}5 = \frac{n}{0{,}03}$

$n = 0{,}015$ mol

$(COOH)_2 : NaOH$
1 : 2
0,015 : 0,03

Base: $C = \frac{n}{V} = \frac{0{,}03}{0{,}025}$
$= 1{,}20\ mol{\cdot}dm^{-3}$

4.1 $2HC\ell + Na_2CO_3 \rightarrow 2NaC\ell + H_2O + CO_2$

4.2 base: $C = \frac{n}{V}$

$0{,}1 = \frac{n}{0{,}025}$

$n = 2{,}5 \times 10^{-3}$ mol

$Na_2CO_3 : HC\ell$
1 : 2
$2{,}5 \times 10^{-3} : 5 \times 10^{-3}$

Acid: $C = \frac{n}{V} = \frac{5 \times 10^{-3}}{0{,}035}$
$= 0{,}14\ mol{\cdot}dm^{-3}$

Practical Activity – page 169

Investigation 1:

1.

Temp of HCℓ	Temp of NaOH	Temp of mixture at start	Temp of mixture at end	Change in temp
22	22	22	31	31

2. $HC\ell + NaOH \rightarrow NaC\ell + H_2O$
3. Exothermic. Temperature on the thermpmeter increased
4. Energy is released to the water particles when the product forms and this causes the reading on the thermometer to increase.

Investigation 2:

1.

Temp of HCℓ	Temp of NaOH	Temp of mixture at end	Change in temp
21	21	14	7

2. Endothermic. Energy absorbed to break the bonds more than energy released to form new bonds.

Activity 1
Bond energy in chemical reaction – page 171

1. An exothermic reaction is when energy is released to the surroundings during the reaction $HC\ell + NaOH$. The energy of the products is smaller than the energy of the reactants.
   An endothermic reaction is when energy is taken out of the surroundings during the reaction. Example baking bread. The energy of the products is bigger than the energy of the reactants or KNO_3 and H_2O.

2.1 Which chemical reaction, A or B, will have the greater energy exchange?

2.2 The higher concentration of HCl will generate more heat during a reaction.

2.3 Both exothermic- final temperature is higher in both.

2.4 Yes, it is fair. Only one variable was different [HCl] everything else was kept constant.

2.5 Thermometer

2.6 Higher [HCl] will generate more heat if it reacts with a substance.

3.1 exothermic

3.2 exothermic

3.3 endothermic

4.1 negative

4.2 ΔH = E intake – E released
∴ ΔH is negative
More E released than taken in it gets hot.

5.1 Exothermic
ΔH= negative
More E released than taken in it gets hot.

5.2 *Should be number 6.3 as it does not fit here in 5.2*

6.1 Energy needed to break bonds:
4(+413) + 1(+243) = + 1895 kJ·mol^{-1}
Energy needed to form bonds:
3(-413) + 1(-326) + 1(-431)
= -1996 kJ·mol^{-1}
Change in bond energy
= +1895 + (-1996)
ΔH =-101 kJ·mol^{-1}

6.2 This is an exothermic reaction because energy was given off to the surroundings. The energy of the products is lower than the energy of the reactants.
101 kJ·mol^{-1} of energy is released for each mol of product formed.

6.3 $n_{Cl_2} = \frac{m}{M} = \frac{1,6}{71} = 0{,}023\text{ mol}$

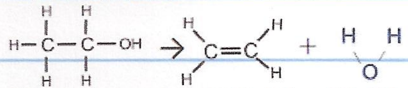
Cl_2 : CH_3Cl : HCl
1 : 1 : 1
0,023: 0,023 : 0,023
Energy taken up = 5,566
Energy released = (39,24 + 0,71)

ΔH = 5,566 - (39,24 + 0,71)
= - 33,745 kJ.mol^{-1}

7.1 E(taken up) = 2[(3x413) + 3(389) +941)] = 9184 kJ
E(released) = 2(941) + 2(745x2) + 6(2x463) = 10418 kJ
ΔE= E(taken up)- E(released)
= 9184 – 10418
= -1234 kJ

7.2 This is an exothermic reaction because energy was given off to the surroundings. The energy of the products is lower than the energy of the reactants.

7.3 - 617 kJ·mol^{-1}

8.1

E(taken up) = 5(C-H) +(C-C) + (C-O) + (O-H)
= 5(413) + (348) +(258) + (463)
= 3134 kJ
E(released) = 4(C-H) + (C=C) + 2(H-O)
= 4(413) + (745) + 2(463)
= 3323 kJ
ΔE= E(taken up)- E(released)
= 3134 – 3323
= -189 kJ

8.2 Exothermic. Energy released is more than the energy taken in.

9.1.1 $NH_4NO_3\text{ (s)} \xrightarrow{H_2O} NH_4^+ + NO_3^-$

9.1.2 $NH_4C\ell\text{(s)} \xrightarrow{H_2O} NH_4^+ + C\ell^-$

9.2 *Bonding energy of N-O is 55 kJ·mol^{-1}*
E(taken up) = 4(N-H) + 3(N-O)
= 4(389) + 3(55)
= 1721 kJ

9.3 E(taken up) = 4(N-H)
= 4(389)
= 1556 kJ

9.4 Endothermic. More energy was taken in than was released. The pack becomes cold.

9.5 As soon as the water and the solid get into contact, dissolution occurs. More energy is taken in than released. This gives the cooling effect of the pack.

9.6 NH_4NO_3. More energy is needed to be taken in. It is therefore a colder ice pack.

9.7 $n = \frac{m}{M} = \frac{30}{80} = 0{,}375\text{ mol}$
1 mol is 26 kJ
So 0,375 mol is 9,75 kJ·mol^{-1}

10.1.1 Liquid

10.1.2 Solid

10.2 The reaction is endothermic. Reactants take in more energy than what the products release. This cause a temperature of the reaction to drop to such a extend that the contents goes below 0°C causing the surroundings water to freeze the plank and the flask together. The intermolecular forces keep them frozen.

10.3 ΔH = E(taken in) – E(released)
=(1437 + 2334 + 9360)-(8394+3427)
= + 1246 kJ

10.4 Endothermic. Energy absorbed is more than the energy released.

10.5 It would be less than when it started (original)

11.1 CO_2 (s) → CO_2 (g)

11.2 It goes immediately from solid phase to the gaseous phase (skipping the liquid phase)

11.3 Gas fills the space it occupies. Gas particles collide and move chaotically.

11.4 E(reactant) = 2(C=O) = 2(745)
= 1490 kJ

11.5 Endothermic. More energy was absorbed than released. Reactants have more energy than products.

11.6 ΔH = H(products) – H(reactants)
98 = H(products) – 1490
H(products) = 1588 kJ

Activity 2
More about energy in chemical reactions – page 182

1.1 Exothermic – the surrounding area warms up so energy was given off

1.2 Exothermic – the surrounding area warms up so energy was given off

1.3 endothermic – the surrounding area cools down

1.4 Exothermic – the surrounding area warms up so energy was given off

1.5 endothermic – the surrounding area cools down

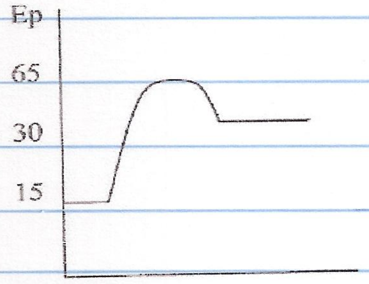
1.6 endothermic – the surrounding area cools down

2.1 coal: 394 $kJ\cdot mol^{-1}$
alcohol: 1367 $kJ\cdot mol^{-1}$
petrol: 5470 $kJ\cdot mol^{-1}$
butane gas: 2636 $kJ\cdot mol^{-1}$

2.2 Petrol. It releases the most energy per mole.

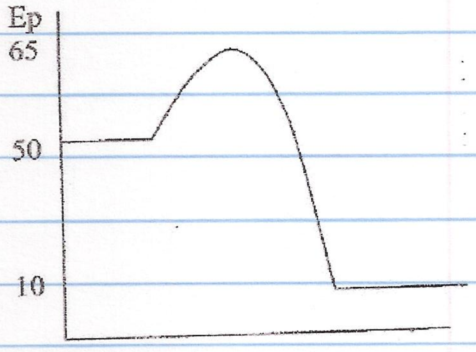
3. Minimum energy needed to start a reaction

4.1



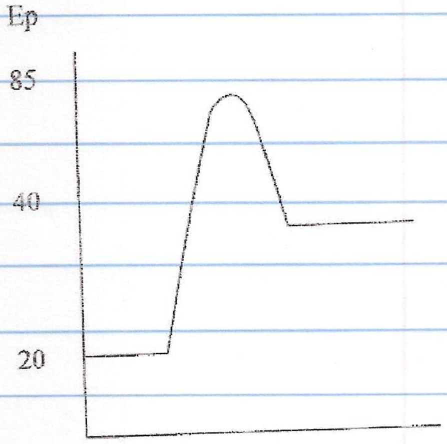
ΔH = 15 $kJ\cdot mol^{-1}$/ endothermic

4.2



ΔH = -40 $kJ\cdot mol^{-1}$/exothermic

4.3



ΔH = 20 $kJ\cdot mol^{-1}$/endothermic

5.1 endothermic, ΔH = positive

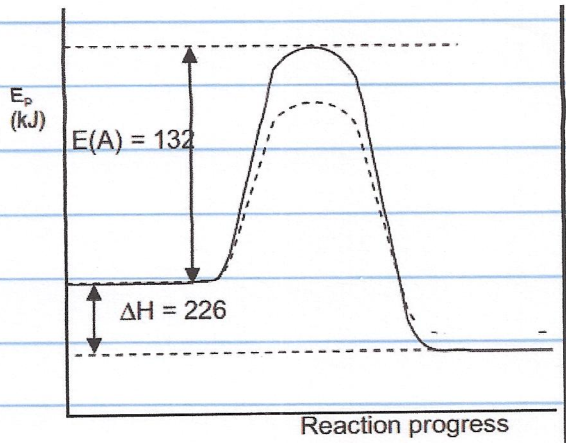
5. 2 activation energy of the forward reaction

5.3 Enthalpy (ΔH)

5.4 activated complex

6. A substance that changes the rate of a chemical reaction without itself changing during the reaction

7.1+
7.2



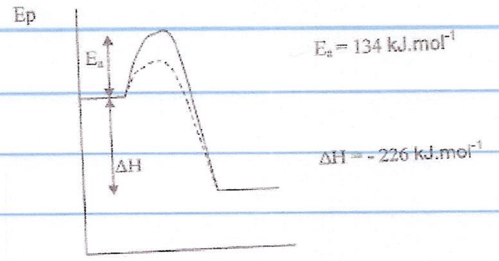
8.1 Exothermic – product energy is lower than the reactants energy.

8.2 1)activation energy for the forward uncatalized reaction
2) energy given off as product form
3) enthalpy
4) The difference in energy between catalysed and uncatalyzed reaction.

9.1.1 360 kJ·mol^{-1}
9.1.2 240 kJ·mol^{-1}
9.1.3 360 kJ·mol^{-1}
9.1.4 120 kJ·mol^{-1}

9.2 It will be the same. A catalyst lowers the activitation energy, but has no effect on the ΔH value.

10.1
+
10.2



10.3 134 kJ·mol^{-1}
10.4 Exothermic

11.1 exothermic , energy of the product is lower than that of the reactants

11.2 increase the rate of the reaction because the activation energy needs to decrease

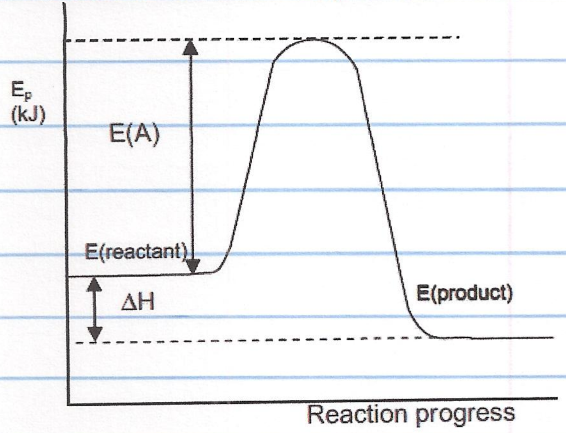
11.3 When you exercise the body takes in more oxygen which has the effect of more glucose being broken down. More energy is released to the body and less glucose is stored as fat.

12. Exothermic – enough energy is given off for the reaction to use this energy again as activation for the next reaction taking place.

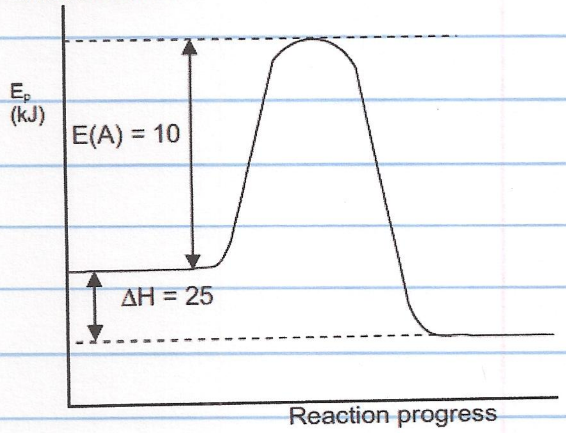
13.1 $Fe+O_2 \xrightarrow{c} Fe_2O_3$

13.2 Exothermic-release temperature.

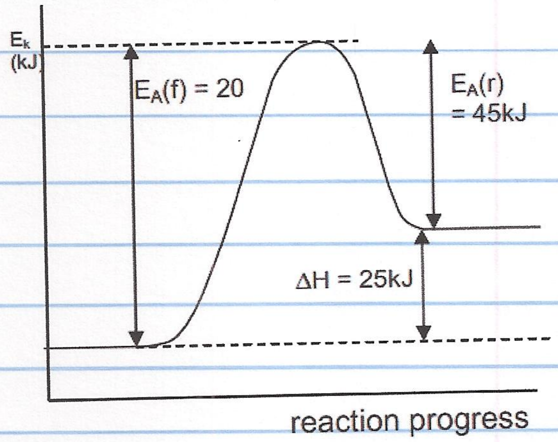
13.3



13.4 HCℓ (aq)will be the product.
13.5 Fertilisers, swimming pool acids
14. 55kJ
15. Endothermic
16.



17.



18.1 I - exothermic II - endothermic
18.2 I increase temperature
II decrease temperature

Activity 1
Acid – base reactions – page 201

1. Acid:
   (1) HCℓ - strong
   (2) HNO_3 – strong
   (3) H_2SO_4 – strong
   (4) CH_3COOH – weak
   Base:
   KOH – strong
   Na_2CO_3 – weak
   NaOH – strong
   NH_3 – weak
2. Ionises almost completely in H_2O to form high $[H_3O]^-$
3. Ionises only partially in H_2O to form low $[H_3O]^+$
4. $\frac{\text{high [acid]}}{\text{dm}^3\text{of solution}}$
5. $\frac{\text{low [acid]}}{\text{dm}^3\text{of solution}}$

6.1 $H_2SO_4 + H_2O \rightleftharpoons H_3O^+ + SO_4^{-2}$

6.2 $CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$

6.3 $HC\ell + H_2O \rightleftharpoons H_3O^+ + C\ell^-$

7.

H_2SO_4	SO_4^{-2}	H_3O^+
Low	High	High
HCℓ	H_3O^+	$C\ell^-$
Low	High	High
CH_3COOH	CH_3COO^-	H_3O^+
High	Low	Low

8. Strong base – dissociates almost completely in H_2O, high $[OH^-]$.
   Weak base - dissociates only partially in H_2O, low $[OH^-]$.

9.

	Arrhenius- model
Acid	Substance that releases H^+ ions in an aqueous solution
Base	Substance that releases OH^- ions in an aqueous solution

	Bronstead- Lowry theory
Acid	A proton donor
Base	A proton acceptor

	Lewis Theory
Acid	Accepts an electron in formation of chemical bond
Base	Donates an electron in formation of chemical bond

10. Limits substances to aqueous solutions.

11.1 Proton transfer

11.2 Protolysis

12. The substance that differs from the acid with one less hydrogen

13.1 OH^-

13.2 NO_3^-

13.3 NH_3

13.4 HCO_3^-

13.5 CO_3^{2-}

13.6 $C\ell^-$

13.7 $H_2PO_4^-$

13.8 SO_4^{2-}

13.9 S^{2-}

13.10 HPO_4^{2-}

14. It is the product that differs from the base with one more hydrogen.

15.1 $HCrO_4^-$

15.2 HNO_3

15.3 H_2SO_4

15.4 H_2O

15.5 H_3PO_4

15.6 HCℓ

15.7 OH^-

15.8 HSO_4^-

15.9 H_3O^+

15.10 NH_4^+

16.1 weak

16.2 weak

17.1 $H_2O \rightarrow H^+ + OH^-$

17.2 $H_3O^+ \rightarrow H^+ + H_2O$

17.3 $H_2SO_4 \rightarrow H^+ + HSO_4^-$

17.4 $HSO_4^- \rightarrow H^+ + SO_4^{2-}$

18.1 $H_2O + H^+ \rightarrow H_3O^+$

18.2 $OH^- + H^+ \rightarrow H_2O$

18.3 $NH_3 + H^+ \rightarrow NH_4^+$

18.4 $SO_4^{2-} + H^+ \rightarrow HSO_4^-$

19.1

$$\underset{\text{base}}{NH_3} + \underset{\text{acid}}{HC\ell} \rightarrow \underset{\text{conj acid}}{NH_4^+} + \underset{\text{conj base}}{C\ell^-}$$

19.2

$$\underset{\text{acid}}{HC\ell} + \underset{\text{base}}{H_2O} \rightarrow \overset{\text{conj base}}{C\ell^-} + \underset{\text{conj acid}}{H_3O^+}$$

19.3

$$\underset{\text{base}}{CO_3^{2-}} + \underset{\text{acid}}{H_2O} \rightarrow \overset{\text{conj acid}}{HCO_3^-} + \underset{\text{conj base}}{OH^-}$$

19.4 *It should be HSO_3^-*

$$\underset{\text{base}}{OH^-} + \underset{\text{acid}}{HSO_3^-} \rightarrow \overset{\text{conj acid}}{H_2O} + \underset{\text{conj base}}{SO_3^{2-}}$$

19.5

$$\underset{\text{base}}{OH^-} + \underset{\text{acid}}{NH_4^+} \rightarrow \overset{\text{conj acid}}{H_2O} + \underset{\text{conj base}}{NH_3}$$

20.

protolytic reactions	**Acids**	**Bases**
14.1	H_3O^+; H_2CO_3	HCO_3^- H_2O
14.2 *Error in book*	HCO_3^- H_2O	OH^- CO_3^{2-}
14.3	$HC\ell$ NH_4^+	NH_3 $C\ell^-$
14.4	$HSeO_3^-$ NH_4^+	SeO_3^{-2} NH_3
14.5	$C_5H_5NH^+$ H_3O^+	H_2O C_5H_5N

21.1 Substance that can act as an acid or a base

21.2 H_2O; HSO_4^-

21.3 1) HCO_3^- forms CO_3^{2-} or H_2CO_3
2) HPO_4^{2-} forms PO_4^{3-} or $H_2PO_4^-$
3) $H_2PO_4^-$ forms HPO_4^{2-} or H_3PO_4

22.1 $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

22.2 $2H^+(aq) + SO_4^{2-}(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow 2K^+(aq) + SO_4^{2-}(aq) + 2H_2O(\ell)$

22.3 $2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(\ell)$

22.4 Protolysis

23.1 $2HC\ell + Mg \rightarrow MgC\ell_2 + H_2$

23.2 $2HC\ell + Ca(OH)_2 \rightarrow CaC\ell_2 + 2H_2O$

23.3 $H_2SO_4 + Mg(OH)_2 \rightarrow MgSO_4 + 2H_2O$

23.4 $2HNO_3 + K_2O \rightarrow 2KNO_3 + H_2O$

23.5 $2H_3PO_4 + 3Na_2CO_3 \rightarrow 2Na_3PO_4 + 3H_2O + 3CO_2$

23.6 $2CH_3COOH + MgO \rightarrow Mg(CH_3COO)_2 + H_2O$

23.7 $3Li_2CO_3 + 2H_3PO_4 \rightarrow 2Li_3PO_4 + 3H_2O + 3CO_2$

23.8 $H_2CO_3 + CuO \rightarrow CuCO_3 + H_2O$

23.9 $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

23.10 $CaCO_3 + 2HC\ell \rightarrow CaC\ell_2 + H_2O + CO_2$

24.1 $Zn + 2HC\ell \rightarrow ZnC\ell_2 + H_2$

24.2 $NaOH + HC\ell \rightarrow NaC\ell + H_2O$

24.3 $HC\ell + NaHCO_3 \rightarrow NaC\ell + H_2O + CO_2$

24.4 $H_2SO_4 + Mg \rightarrow MgSO_4 + H_2$

24.6 $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

25.1 H_2SO_4

25.2 *Should read :write the chemical name for sulphuric acid"*
Hydrogen sulphate

25.3 Strong $[H^+]$ The acid still ionises completely in water.

25.4 $H_2SO_4 + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$

25.5 Exothermic, heat is given off. More energy was given off as the products formed than the energy needed to break the bonds of the reactant

25.6 Hydrogen chloride / Jik / swimming pool acid

25.7 $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

25.7 $n_b = \frac{m}{M} = \frac{500}{84} = 5{,}95\text{ mol} = c_b v_b$

$$\frac{n_a}{n_b} = \frac{c_a v_a}{c_b v_b}$$

$$\frac{1}{1} = \frac{5 \times v_a}{5{,}95}$$

$$v_a = 1{,}19\text{ dm}^3 = 1190\text{ cm}^3$$

26.1 Any strong base - NaOH

26.2 Acid reacted with metal (Fe)
$HCl + Fe \rightarrow FeCl_2 + H_2$

26.3 Salt + $H_{2(g)}$ was produced

26.4 $2HCl + Fe \rightarrow FeCl_2 + H_2$

26.5 Take a sample of river water and add bromothymol blue to the water. If it turns yellow, it most probably got into the water of the river.

27.1 pH is the log of the reciprocal of $[H_3O^+]$ ions in the solution.

27.2 OH^- concentration or H^+ concentration

27.3 $pH = -\log[H_3O^+]$ or $pH = \frac{1}{\log[H_3O^+]}$

27.4 (1) <7
(2) >7
(3) 7

27.5 7, $[H_3O^+]$ and $[OH^-] = 1 \times 10^{-7}$

27.6 No

28.1 Caustic soda

28.2 Pain killers and vinegar

28.3 Water and sugar water

28.4 (2) and (4)

28.5 $[OH^-]$

28.6 Acidic, can burn your stomach.

28.7 To neutralise or increase the acid in the mouth

28.8 Brush teeth often after eating sweets.

29.

pH	$[H_3O^+]$	$[OH^-]$
3	10^{-3}	10^{-11}
2	10^{-2}	10^{-12}
8	10^{-8}	10^{-6}
11	10^{-11}	10^{-3}

30.1 *29.1*
$pH = -\log[H^+]$
$= -\log 10^{-4}$
$= 4$

30.2 *29.2*
$pH = -\log[H^+]$
$= -\log 0{,}001$
$= 3$

30.3 *29.3*
$[H^+][OH^-] = 1 \times 10^{-14}$
$[H^+] = 1 \times 10^{-8}$
$pH = -\log[H^+]$
$= -\log 10^{-8}$
$= 8$

30.4 *29.4*
$[H^+][OH^-] = 1 \times 10^{-14}$
$[H^+] = 1 \times 10^{-1}$
$pH = -\log[H^+]$
$= -\log 10^{-1}$
$= 1$

31.1 *30.1* $[H^+] = 10^{-pH}$
$= 10^{-14}\ mol \cdot dm^{-3}$

31.2 *30.2* $[H^+] = 10^{-pH}$
$= 10^{-11}\ mol \cdot dm^{-3}$

31.3 *30.3* $[H^+] = 10^{-pH}$
$= 10^{-3}\ mol \cdot dm^{-3}$

31.4 *30.4* $[H^+] = 10^{-pH}$
$= 10^{-7}\ mol \cdot dm^{-3}$

32.1 *31.1* $[H^+] = 10^{-pH}$
$= 10^{-3}\ mol \cdot dm^{-3}$
$[H^+][OH^-] = 1 \times 10^{-14}$
$10^{-3}[OH^-] = 1 \times 10^{-14}$
$[OH^-] = 10^{-11}\ mol \cdot dm^{-3}$

32.2 *31.2* $[H^+] = 10^{-pH}$
$= 10^{-9}\ mol \cdot dm^{-3}$
$[H^+][OH^-] = 1 \times 10^{-14}$
$10^{-9}[OH^-] = 1 \times 10^{-14}$
$[OH^-] = 10^{-5}\ mol \cdot dm^{-3}$

32.3 *31.3* $[H^+] = 10^{-pH}$
$= 10^{-12}\ mol \cdot dm^{-3}$
$[H^+][OH^-] = 1 \times 10^{-14}$
$10^{-12}[OH^-] = 1 \times 10^{-14}$
$[OH^-] = 10^{-2}\ mol \cdot dm^{-3}$

32.4 *31.4* $[H^+] = 10^{-pH}$
$= 10^{-6}\ mol \cdot dm^{-3}$
$[H^+][OH^-] = 1 \times 10^{-14}$
$10^{-6}[OH^-] = 1 \times 10^{-14}$
$[OH^-] = 10^{-8}\ mol \cdot dm^{-3}$

33.1 *32.1* $HC\ell + H_2O \rightarrow H_3O^+ + C\ell^-$
$pH = -\log[H^+]$
$= -\log 10^{-2}$
$= 2$

33.2 *32.2* $H_3PO_4 + 3H_2O \rightarrow 3\ H_3O^+ + PO_4^{-3}$
$pH = -\log[H^+]$
$= -\log (0{,}03)$
$= 1{,}5$

33.3 *32.3* $KOH \xrightarrow{H_2O} K^+ + OH^-$
$[H^+][OH^-] = 1 \times 10^{-14}$
$[H^+](0{,}001) = 1 \times 10^{-14}$
$[H^+] = 10^{-11}\ mol \cdot dm^{-3}$
$pH = -\log[H^+]$
$= -\log 10^{-11}$
$= 11$

33.4 *32.4* $Ca(OH)_2 \rightarrow 2OH^- + Ca^{2+}$
$[H^+][OH^-] = 1 \times 10^{-14}$
$[H^+](0{,}2) = 1 \times 10^{-14}$
$[H^+] = 5 \times 10^{-14}\ mol \cdot dm^{-3}$
$pH = -\log[H^+]$
$= -\log (5 \times 10^{-14})$
$= 13{,}3$

Activity 2
Redox-reaction - page 215

1.1 electron donor

1.2 electron acceptor

1.3 The substance that undergoes reduction

1.4 The substance that undergoes oxidation

1.5 A reaction where reduction and oxidation takes place.

2.1 $Mg \rightarrow Mg^{2+} + 2e^-$

2.2 $Cu^{2+} + 2e^- \rightarrow Cu$
2.3 $Cu^{2+}(aq)$
2.4 Mg (s)
3.1 $Zn \rightarrow Zn^{2+} + 2e^-$
3.2 $Fe^{2+} + 2e^- \rightarrow Fe$
3.3 $Fe^{2+}(aq)$
3.4 Zn(s)
4.1 $Sn \rightarrow Sn^{2+} + 2e^-$
4.2 $2Ag^+ + 2e^- \rightarrow 2Ag$
4.3 $Ag^+(aq)$
4.4 Sn
5.1 $Ca \rightarrow Ca^{2+} + 2e^-$
5.2 $A\ell^{3+} + 3e^- \rightarrow A\ell$
5.3 $A\ell^{3+}$
5.4 Ca
6.1 $Fe \rightarrow Fe^{3+} + 3e^-$
6.2 $I_2 + 2e^- \rightarrow 2I^-$
6.3 I_2
6.4 Fe(s)
7.1.1 $Cu \rightarrow Cu^{2+} + 2e^-$
7.1.2 $C\ell_2 + 2e^- \rightarrow 2\,C\ell^-$
7.1.3 Cu
7.1.4 $C\ell_2$
7.2.1 $Br_2 + 2e^- \rightarrow 2Br^-$
7.2.2 $Zn \rightarrow Zn^{2+} + 2e^-$
7.2.3 Br_2
7.2.4 Zn
7.3.1 $Ca \rightarrow Ca^{2+} + 2e^-$
7.3.2 $I_2 + 2e^- \rightarrow 2I^-$
7.3.3 Ca
7.3.4 I_2
8.1 1) Mn
2) Hg^{2+}
3) Hg^{2+}
4) Mn
8.2 1) Cr^{2+}
2) Br_2
3) Br_2
4) Cr^{2+}
8.3 1) H_2
2) Sn^{4+}
3) Sn^{4+}
4) H_2
8.4 1) Fe^{2+}
2) Sn^{4+}
3) Sn^{4+}
4) Fe^{2+}
8.5 1) Li
2) F_2
3) F_2
4) Li
9.1 $Mg(s) + 2H^+ + 2C\ell^- \rightarrow Mg^{2+} + 2C\ell^- + H_2$
9.2 $Mg \rightarrow Mg^{2+} + 2e^-$
$2H^+ + 2e^- \rightarrow H_2$
$2C\ell^- \rightarrow 2C\ell^-$
9.3 Mg
9.4 H^+
9.5 Transfer of electrons
9.6.1 $Mg \rightarrow Mg^{2+} + 2e^-$
9.6.2 $2H^+ + 2e^- \rightarrow H_2$
9.6.3 H^+
9.6.4 Mg
10.1 Fe oxidation number changed from 0 to +2 in Fe^{2+} and H's oxidation number change from +1 to 0
yes this is a redox reaction because there is a transfer of electrons
10.2 No change in oxidation number
No redox reaction
10.3 There is a change in oxidation number therefore this is a redox reaction. Mg changes from 0 to +2 in Mg^{2+} and $C\ell_2$ changes from 0 to -1 in $C\ell^-$
10.4 No redox reaction takes place as there is no change in the oxidation number.

Redox reactions in terms of oxidation numbers – page 218

1.1 Increase in oxidation numbers
1.2 Decrease in oxidation numbers
2.1.1 +5
2.1.2 +3
2.1.3 +6
2.1.4 +3
2.1.5 -3
2.1.6 -3
2.1.7 -1
2.1.8 -3
2.1.9 -8/3
2.1.10 +3/2
2.1.11 +5
2.1.12 +3
2.1.13 +7
2.1.14 -2
2.1.15 -3
2.1.16 +3
2.1.17 -4/3
2.1.18 0
2.1 $\mathbf{C\ell O_2 + C \rightarrow C\ell^- + CO_3^{2-}}$
+4 0 -1 +4
C oxidised
2.2 $\mathbf{MnO_4^- + C_2O_4^{2-} \rightarrow MnO_2 + CO_2}$
+7 +3 +4 +4
C^{3+} oxidised

2.3 $\mathbf{Sn^{2+} + C\ell^- + BrO_3^- \rightarrow SnC\ell_6^{2-} + Br^-}$

+2 -1 +5 +4 -1

Sn^{2+} oxidised

2.4 $NO_3^- + H_2\mathbf{Te} \rightarrow \mathbf{NO} + \mathbf{TeO_4^{2-}}$

+5 -2 +2 +6

Te oxidised

3.1 $I_2 + H_2S \rightarrow HI + S$

0 0 -2 +1-1 0

Redox reaction; there is electron transfer

3.2 $KC\ell O_3 \rightarrow KC\ell + O_2$

+1+5-3 +1 -1 0

Redox reaction; there is electron transfer

3.3 $Zn + Cr_2O_7^{2-} + H^+ \rightarrow Zn^{2+} + Cr^{3+} + H_2O$

0 +6 -2 +1 +2 +3 +1 -2

Redox reaction; there is electron transfer

3.4 $HNO_3 + HI \rightarrow NO + I_2 + H_2O$

+1+5-2 +1-1 +2-2 0 +1-2

Redox reaction; there is electron transfer

3.5 $Mg^{2+} + CO_3^{2-} \rightarrow MgCO_3$

+2 +4-2 +2 +4 -2

No redox reaction. Oxidation numbers did not change; so no transfer of electrons took place.

3.6 $2H_2O \rightarrow 2H_2 + O_2$

+1-2 0 0

Redox reaction; there is electron transfer

3.7 $Ag + H_2SO_4 \rightarrow Ag_2SO_4 + SO_2 + H_2O$

0 +1+6-2 +1+6 -2 +4 -2 +1 -2

Redox reaction; there is electron transfer

3.8 $KNO_3 + NaC\ell \rightarrow NaNO_3 + KC\ell$

+1+5-2 +1-1 +1+5-2 +1-1

No redox reaction. Oxidation numbers did not change so no transfer of electrons took place.

4.1 $Cu + C\ell_2 \rightarrow CuC\ell_2$

0 0 +2-1

Cu – oxidised – reducing agent

$C\ell_2$ – reduced – oxidising agent

4.2 $SO_2 + ½ O_2 \rightarrow SO_3$

+4-2 0 +6-2

S – oxidised – reducing agent

O_2 – reduced – oxidising agent

4.3 $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$

+1 -2 0 +4-2 +1 -2

S – oxidised – reducing agent

O_2 – reduced – oxidising agent

4.4 $MnO_2 + 4HC\ell \rightarrow MnC\ell_2 + C\ell_2 + 2H_2O$

+4-2 +1-1 +2-1 0 +1-1

$C\ell_2$ – oxidised – reducing agent

Mn – reduced – oxidising agent

4.5 $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

0 +1-2 +2-2-1 0

Ca – oxidised – reducing agent

H– reduced – oxidising agent

4.6 $I_2O_5 + 5CO \rightarrow I_2 + 5CO_2$

+5-2 +2-2 0 +4-2

C – oxidised – reducing agent

I– reduced – oxidising agent

4.7 $5SO_3^{2-} + 2MnO_4^- + 6H^+ \rightarrow 5SO_4^{2-} + 2Mn^{2+} + 3H_2O$

+4-2 +7-2 +1 +6-2 +2 +1-2

S in SO_3^{2-} – oxidised – reducing agent

Mn in MnO_4^- – reduced – oxidising agent

Activity 3

Reactions in organic chemistry – page 228

1.1 Chemistry of molecules that contain carbon and hydrogen.

1.2 four

2.1 Compounds made up of hydrogen and carbon atoms.

2.2 Compounds made up of hydrogen and carbon with single bonds only.

2.3 Hydrocarbons with single bonds between the carbons.

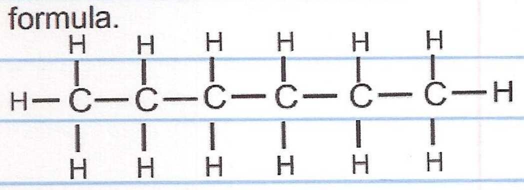
2.4 Hydrocarbons with two or more double bonds between the carbons

2.5 Hydrocarbons with two or more triple bonds between the carbons.

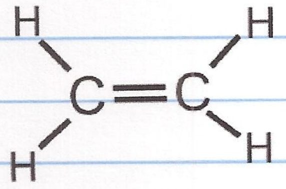
2.6 Compounds with similar functional groups having similar chemical properties

2.7 Different structures of substances that have the same molecular formula.

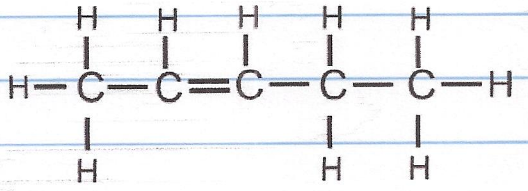
3.1



3.2

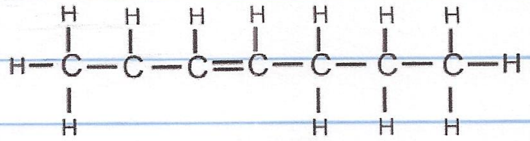


3.3
(3.2)



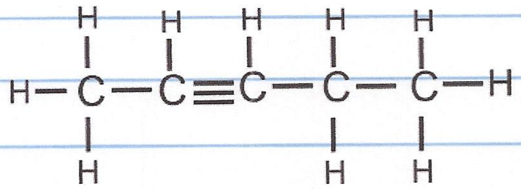
$$\begin{array}{*{13}{c}} & & H & & H & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & = & C & - & C & - & C & - & H \\ & & \mid & & & & & & \mid & & \mid & & \\ & & H & & & & & & H & & H & & \end{array}$$

3.4



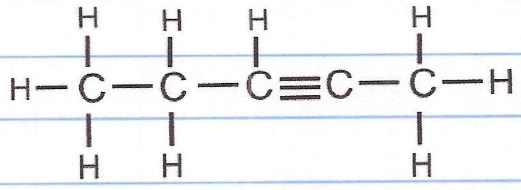
$$\begin{array}{*{17}{c}} & & H & & H & & H & & H & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & - & C & = & C & - & C & - & C & - & C & - & H \\ & & \mid & & & & & & & & \mid & & \mid & & \mid & & \\ & & H & & & & & & & & H & & H & & H & & \end{array}$$

3.5



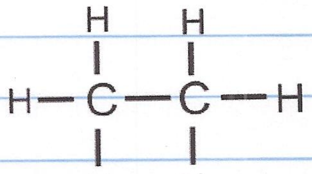
$$\begin{array}{*{13}{c}} & & H & & H & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & \equiv & C & - & C & - & C & - & H \\ & & \mid & & & & & & \mid & & \mid & & \\ & & H & & & & & & H & & H & & \end{array}$$

3.6



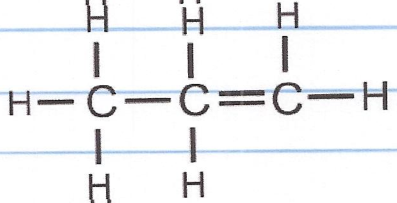
$$\begin{array}{*{13}{c}} & & H & & H & & H & & & & H & & \\ & & \mid & & \mid & & \mid & & & & \mid & & \\ H & - & C & - & C & - & C & \equiv & C & - & C & - & H \\ & & \mid & & \mid & & & & & & \mid & & \\ & & H & & H & & & & & & H & & \end{array}$$

3.7



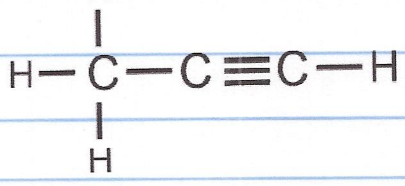
$$\begin{array}{*{7}{c}} & & H & & H & & \\ & & \mid & & \mid & & \\ H & - & C & - & C & - & H \\ & & \mid & & \mid & & \\ & & H & & H & & \end{array}$$

3.8



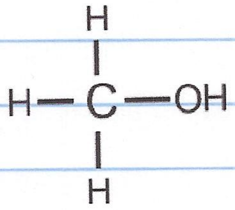
$$\begin{array}{*{9}{c}} & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & = & C & - & H \\ & & \mid & & \mid & & & & \\ & & H & & H & & & & \end{array}$$

3.9



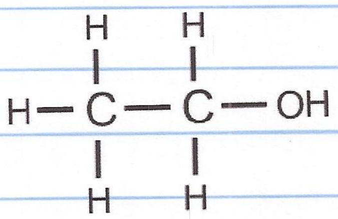
$$\begin{array}{*{9}{c}} & & H & & & & & & \\ & & \mid & & & & & & \\ H & - & C & - & C & \equiv & C & - & H \\ & & \mid & & & & & & \\ & & H & & & & & & \end{array}$$

3.10



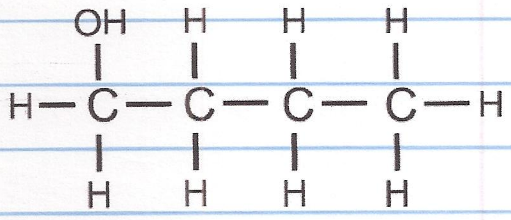
$$\begin{array}{*{5}{c}} & & H & & \\ & & \mid & & \\ H & - & C & - & OH \\ & & \mid & & \\ & & H & & \end{array}$$

3.11



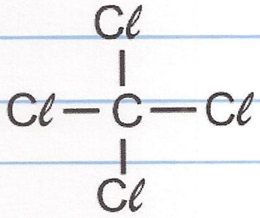
$$\begin{array}{*{7}{c}} & & H & & H & & \\ & & \mid & & \mid & & \\ H & - & C & - & C & - & OH \\ & & \mid & & \mid & & \\ & & H & & H & & \end{array}$$

3.12



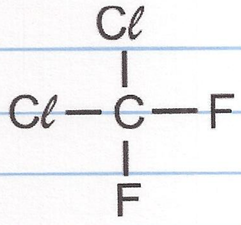
$$\begin{array}{*{11}{c}} & & OH & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & - & C & - & C & - & H \\ & & \mid & & \mid & & \mid & & \mid & & \\ & & H & & H & & H & & H & & \end{array}$$

3.13



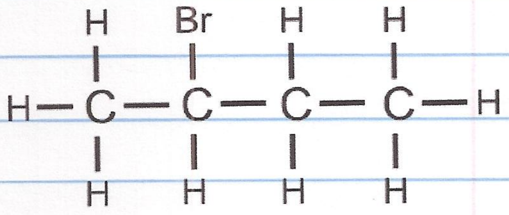
$$\begin{array}{*{5}{c}} & & C\ell & & \\ & & \mid & & \\ C\ell & - & C & - & C\ell \\ & & \mid & & \\ & & C\ell & & \end{array}$$

3.14



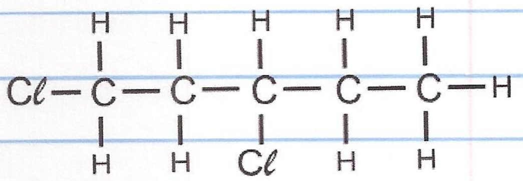
$$\begin{array}{*{5}{c}} & & C\ell & & \\ & & \mid & & \\ C\ell & - & C & - & F \\ & & \mid & & \\ & & F & & \end{array}$$

3.15



$$\begin{array}{*{11}{c}} & & H & & Br & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & - & C & - & C & - & H \\ & & \mid & & \mid & & \mid & & \mid & & \\ & & H & & H & & H & & H & & \end{array}$$

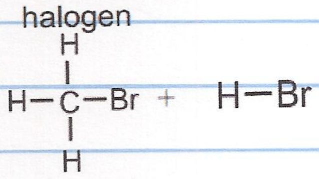
3.16



$$\begin{array}{*{13}{c}} & & H & & H & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \mid & & \\ C\ell & - & C & - & C & - & C & - & C & - & C & - & H \\ & & \mid & & \mid & & \mid & & \mid & & \mid & & \\ & & H & & H & & C\ell & & H & & H & & \end{array}$$

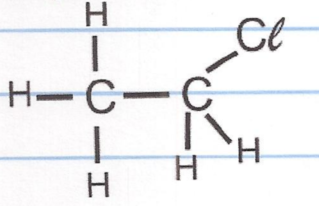
4. It is the reaction of molecules that contain carbon, except CO, CO_2 and the H_2CO_3 where hydrogen has to be removed before being replaced by another substituent.

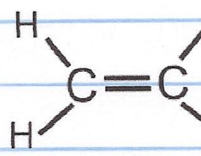
5.1.1 ultra violet light
5.1.2 heat energy
5.1.3 hydrocarbon
5.1.4 halogen
5.2.1

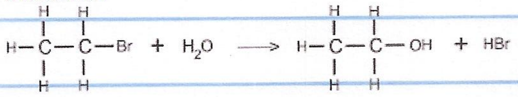


$$\begin{array}{*{9}{c}} & & H & & & & & & \\ & & \mid & & & & & & \\ H & - & C & - & Br & + & H & - & Br \\ & & \mid & & & & & & \\ & & H & & & & & & \end{array}$$

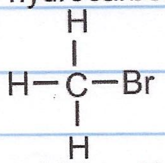
5.2.2 $CH_3Br + HBr$
6.1



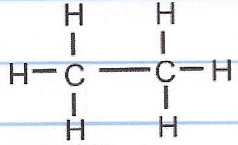
6.2

$+ HCl$

6.3 No water must be present.
7.1 Substitution reaction
7.2 Ethanol and hydrogen bromide
7.3 Alcohol
7.4

$\mathrm{H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Br + H_2O \longrightarrow H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH + HBr}$

8.1 H_2O
8.2 $Cu(H_2O)_4^{+2} + 2C\ell^- \rightarrow CuC\ell_2 + 4H_2O$
8.3 $Cu(H_2O)_4^{+2} + S^{2-} \rightarrow CuS + 4H_2O$
9.1 An addition reaction is when an atom is added to an unsaturated hydrocarbon.

9.2
(9.3)

$\mathrm{H-\overset{H}{\underset{H}{C}}-Br}$

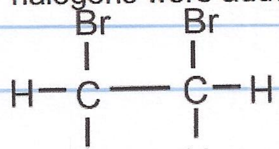
Addition, Hydrogenation, because the double bond in ethane was broken and 2 H – atoms was added.

9.3.1
(9.2.1)

$\mathrm{H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H}$

9.3.2 (9.2.2) CH_3CH_3

9.4 (9.3) The double bonds of unsaturated fats are broken and an alkane that is saturated, is formed.

9.5 (9.4) Halogenation. The double bonds in ethene were broken and two halogens were added.

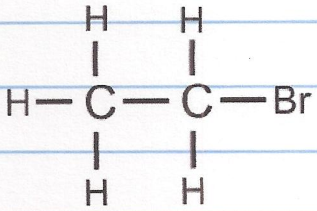
9.6.1
(9.5.1)

$\mathrm{H-\overset{Br}{\underset{H}{C}}-\overset{Br}{\underset{H}{C}}-H}$

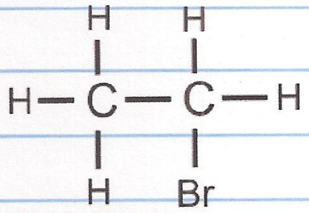
9.6.2 (9.5.2) $CH_2Br\text{-}CH_2Br$

9.7 (9.6) Br_2 is initially brown. The brown colour decolourises as the double bond is broken and the haloalkane forms.

9.8 (9.7) Haloalkane

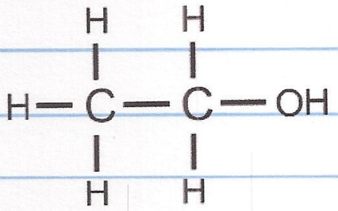
9.9 (9.8) Hydrohalogenation

9.10.1
(9.9.1)

$\mathrm{H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Br}$

9.10.2
(9.9.2)

$\mathrm{H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{Br}{C}}-H}$

9.11 (9.10) Haloalkanes

9.12 (9.11) Hydration reaction

9.13.1
(9.12.2)

$\mathrm{H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH}$

9.13.2 (9.12.2) CH_3CH_2OH

9.14 (9.13) alcohols

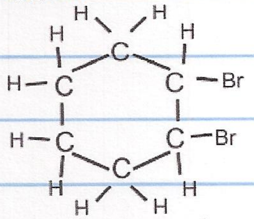
10.1 They have to work in a fume cupboard.
Wear goggles, gloves and a lab coat.

10.2 Cyclohexane is more reactive than cyclohexene if it reacts with bromine.

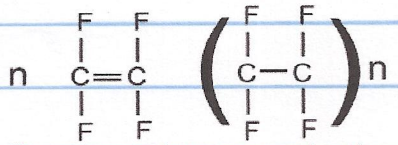
10.3.1 Cyclohexane is a better fuel than cyclohexene because the combustion went to completion.

10.3.2 Cyclohexene reacts faster with bromine than cyclohexane in the presence of light.

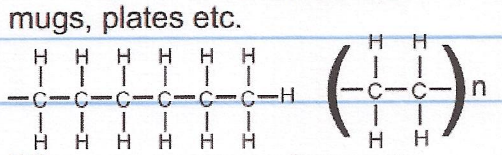
10.4 Substitution reaction because one of the H atoms is replaced by a Br atom.

10.5


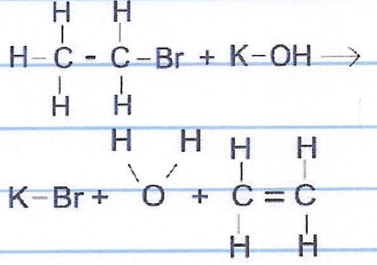
10.6 Addition reaction. Br_2 was added where double bonds is broken.

11.1

$n\,CF_2{=}CF_2 \quad (-CF_2-CF_2-)_n$

11.2 Flooring, table tops, plastic glasses, mugs, plates etc.

11.3

$-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-H \quad (-CH_2-CH_2-)_n$

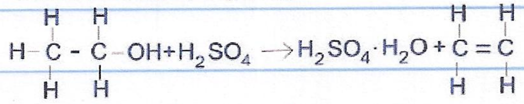
12.1 When one or more atoms are removed from a molecule and an unsaturated hydrocarbon forms (double or triple bonds)

12.2

$CH_3-CH_2-Br + K-OH \rightarrow K-Br + H_2O + CH_2{=}CH_2$

12.3 Dehydrohalogenation

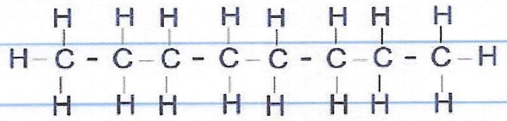
13.1 Removing of the water molecule.

13.2 Concentrated H_2SO_4

13.3

$CH_3-CH_2-OH + H_2SO_4 \rightarrow H_2SO_4\cdot H_2O + CH_2{=}CH_2$

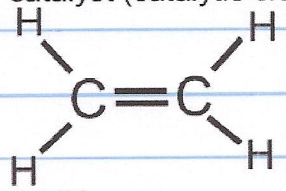
14.1 Breaking of long C-chains into smaller more useful chains.

14.2 Greater percentage yield of useful products of greater fractions of crude oil.

14.3

$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$

14.4 $C_2H_2 + C_6H_{14} + H_2$

14.5 high pressures and temperatures without a catalyst (thermal cracking), or lower temperatures and pressures in the presence of a catalyst (catalytic cracking)

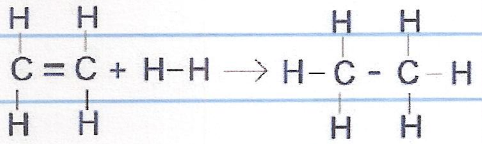
15.1


15.2 Addition

15.3 - The bags were polluting the environment.
- They are a danger to animals. The animals could eat them and die.
- Thin bags were made from ethane, originating from fossil fuels.
Clogging drains, choking livestock
Non-biodegradable
Not suitable for recycling – no commercial value

16.1 Saturated – only single bonds between carbons.
Unsaturated – double and/or triple bonds present.

16.2 An addition reaction where hydrogen is added and bonds to C-atoms where double bonds are broken.

16.3

$CH_2{=}CH_2 + H-H \rightarrow CH_3-CH_3$

16.4.1 Elimination – dehydration

16.4.2 Addition – hydration

16.4.3 Elimination – dehydrohalogenation

16.4.4 Substitution – halogenations

17.1 Is compound X saturated or not?

17.2 Test tubes, Br_2 water, C_5H_{10} solution

17.3 Wear gloves and goggles. Work in a fume cupboard.

17.4
1. Add C_5H_{10} to test tubes labelled X and Y.
2. Do experiment in lightened room.
3. Add few drops of Br_2 water.
4. Observe

17.5 The test tube that decolorize first is the unsaturated bond. The one that takes longer to decolorise is the saturated bond.

17.6 Pent-1-ene

18.1 Elimination reaction. Dehydration of an alcohol. Water was eliminated from molecule

18.2 Addition reaction. Hydrogenation as H_2 was added

18.3 Substitution reaction. The OH ion substituted the Br atom

18.4 Addition reaction. Hydrogenation as H_2 was added

18.5 Elimination reaction. $HC\ell$ was eliminated.

18.6 Addition reaction. Hydration as H_2O was added

18.7 Elimination reaction. Dehydration. Water was eliminated.

18.8 Elimination reaction. $C\ell^-$ and H^+ are eliminated.

19. $CH_3(CH_2)_{10}CH_3 \xrightarrow{cracking} CH_3(CH_2)_6CH_3 + CH_2{=}CH_2$